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JANUARY, 1931 LOUISIANA BULLETIN 220

HOME CANNING OF MEAT UNDER CONDITIONS IN LOUISIANA

BY
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AND
AGRICULTURAL AND MECHANICAL COLLEGE
AGRICULTURAL EXPERIMENT STATIONS

C. T. DOWELL, Dean and Director.

HOME CANNING OF MEATS UNDER CONDITIONS IN LOUISIANA*

GERTRUDE SUNDERLIN
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INTRODUCTION

Canning of meat in the farm home is an important way of helping in the family food budget and in obtaining a better balanced diet. When meat is butchered on the Louisiana farm in the winter, it keeps for a short time only, on account of the variation in winter temperatures. To be kept for future use the meat must be either cured or canned. It cannot be frozen for winter use as it is in the northern farm homes. If sold to the market, it brings a much smaller price than the price the farmer must pay for meat for table use. Increasing the meat consumption on the farm would be especially desirable in pellagrous districts, as lean meat in the diet helps in preventing pellagra. Canning meat is one way of increasing meat consumption on the farm as it gives an easily available supply of meat throughout the year.

Meat canning is encouraged by the Extension Service of Louisiana State University. Canning club records show that in 47 parishes in the state the women and girls canned 101,352 quarts of meat and fish in the year 1930.

HISTORICAL

In many of the southern states there is the opinion that glass jars are unsatisfactory for meat canning. From a 1930 Texas bulletin (1) we have the recommendation "All meats should be canned in tin and in a steam pressure cooker or canner in order that they may be completely sterilized." In a 1929 Florida bulletin (2) "it is recommended that for greater convenience and safety, meats be canned in tin as far as possible." From a 1929 Louisiana bulletin (3) is the statement that "it is the consensus of opinion (though not backed by experimental evidence) among those who have had experience in home canning of meats on the farm under Louisiana conditions that from the standpoint of safety it is preferable to use the steam pressure canner rather than the water bath, and to can in tin cans instead of glass jars."

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*The author wishes to acknowledge the valuable cooperation of Mr. J. B. Francioni, Jr., of the Animal Industry Department.

These opinions may result from the time when rubber rings were more apt to be of poor quality, as indicated in the following quotation from a 1919 United States Department of Agriculture bulletin (4) "Another objection to the use of glass jars is that the rubber rings often are of inferior quality and even good rubber rings are liable to deteriorate in a warm, moist climate if stored for any length of time." Another U. S. D. A. bulletin (5) revised in 1924 contains the greater part of the direction given under "canning in tin cans" in the earlier bulletin, but does **not** contain the above quotation.

Although there are advantages and disadvantages in using glass for canning and in using tin, there is now no experimental evidence for the belief that the factor of safety or of spoilage need enter into the consideration. Recognizing that this **is** a consideration in the minds of many people, and believing that more farm women would be able to can meat if they could use glass jars, the present investigation undertook to secure some experimental evidence on the point in question.

Other points on which information was sought were the length of processing periods which will successfully keep meat canned in Louisiana in the winter and stored through the summer months, and the effect of different storage conditions and storage temperatues on the keeping of the meat.

In a meat canning experiment carried on in Iowa (6) a three hour processing in the boiling water bath was found to be suffcient to successfully keep meat canned in pint jars under conditions prevailing in that state.

EXPERIMENTAL

Material and Methods.

Meat dressed and cut under conditions on a farm was canned in February, 1929 and 1930, and stored seven to nine months including the summer months. A total of 779 cans and jars were canned.

The meat was secured from the Animal Industry Department of the University; it was dressed and cut through the courtesy of Mr. J .B. Francioni Jr. The meat canned in 1929 was from animals that had been killed less than 24 hours, while that canned in 1930 had been in cold storage not more than 4 days.

Number 2 tin cans and pint Mason Jars were used. The cans were sealed with lids having composition gaskets in the 1929 experiments and with lids having paper gaskets in 1930. The jars were sealed with new rubber rings and new zinc caps.

Both beef and pork were used. There were 395 pounds canned in 1929 and 384 pounds canned in 1930. Half was canned in tin and half in glass; half was processed in the pressure cooker and half in the boiling water bath; half was stored at room temperature and half was stored in a basement. The lengths of the different processing periods used in the pressure cooker were 45 minutes and 60 minutes at 15 pounds pressure, and in the boiling water bath were 3 hours and 4 hours.

The meat was cut into pieces convenient size for serving, 453 gram (1 pound) portions were weighed, browned in a frying pan and packed into hot jars and cans. One half cup of hot water was put into the frying pan to make an unthickened brown sauce. When boiling, this was poured over the meat. Boiling water was added, if necessary, to fill the jar or can to within one inch of the top. One teaspoon of salt was added. The jars were sealed to within one-half inch of a complete seal if they were to be processed in the hot water bath and almost completely sealed if to be processed in the pressure cooker. The jars and cans were processed for stated lengths of time in the hot water bath or the pressure cooker, using half jars and half cans in each lot. In the use of the pressure cooker the precaution of allowing the petcock to remain open seven minutes after the appearance of steam was observed, since it has been shown that this is important in getting the desired temperature. (6) Timing the processing was started when the pressure gauge registered 15 pounds. At the close of the processing, the petcock was opened only a little, to allow the pressure to decrease gradually. In the use of the boiler, the jars and cans were submerged in enough boiling water to cover the tops at least three inches, and the timing was started when the water reached a "jumping boil." After removing from the cooker or boiler the seal was completed on the jars. The cans were plunged into cold water to assist in cooling. After standing over-night half the jars and half the cans from each lot were stored in the basement and the other half at room temperature.

The storage temperature variation for the cans and jars stored at room temperature was practically that of the outside air. In the summer occasionally it reached as high as 98 °F. This temperature would give good opportunity for bacterial growth. However in many Louisiana homes there is no opportunity for a storage place cooler than room temperatures. In the basement used in 1929 the temperature reached as high as 80 °F on some of the hottest summer days. The temperature of the basement room used in 1930 was only about 5° to 8° lower than outside temperatures in the hot weather. The basement used in 1929 was damp, while the basement room used in 1930 was comparatively dry.

In determining spoilage after the storage period had elapsed the following tests were used: general appearance of the jar or can and of the meat, suction, odor, pH, titrable acidity, ammonia and amino nitrogen as determined by the Sorenson formol titration, microscopic examination of the sediment, and an attempt to cultivate bacteria in dextrose agar containing Andrade's indicator.

Results.

Meat Canned in 1929.

No spoilage which was attributed to underprocessing occurred. The 3 and 4 hour process in the boiling water bath, as well as the 45 and 60 minutes at 15 pounds pressure were found to be satisfactory processing periods under the conditions of the experiment. No imperfect seals or leaks were found in any of the glass jars. No rubber rings had deteriorated to break the seal.

Spoilage occurred in 13 of the 192 tin cans. That this spoilage was due to leaks rather than underprocessing was shown by one or more of the following tests:

(1) Bubbles arose when can was immersed in hot water for five minutes.

(2) Microscopic examination of liquid showed mixed cultures including cocci as well as rods.

(3) Bacteria isolated from the spoiled cans were non heat-resistant cocci.

The 13 cans in which there was spoilage due to leaks were divided as follows:

Processing periods:

2 had been processed 3 hours in boiling water bath.
2 had been processed 4 hours in boiling water bath.
3 had been processed 45 minutes at 15 lbs. pressure.
6 had been processed 60 minutes at 15 lbs. pressure.

Spoilage occurred the most frequently in those cans which had the longest processing period. This was, of course, contrary to expectations. One possible explanation was destruction of the composition in the composition gaskets by the long period of heating. This explanation was not substantiated however by sealing tests which were made later. In the sealing tests, 200 cans containing hot beef broth were sealed, 100 with composition gaskets and 100 with paper gaskets, to determine whether or not there was a difference in the quality of the seal formed by the two types of gaskets. The cans were processed at 15 pounds pressure for 60 minutes, and stored. In this trial, no difference in the seals was found. Another possible explanation of the imperfect seals is that the can sealer might have been slightly out of adjustment at times. The belief that the latter may be the correct explanation of part of the leaks is strengthened by the fact that spoilage occurred in cans sealed on only three of the five days of canning.

Storage conditions:

Contrary to expectations, more spoilage occurred with those cans stored at cooler temperatures. However, none of the storage rooms were cool. Nine of the cans which spoiled had been stored in the basement and 4 had been stored at room temperature. The dampness of the basement may have been the important factor here as some of the cans had rust spots. Rusted cans are apt to allow pinhole perforations.

Meat Canned in 1930.

No spoilage occurred in any of the 192 cans of meat. No spoilage due to imperfect seals or leaks occurred in any of the 192 jars. Two jars of beef processed 3 hours in the boiling water bath and stored in the basement room spoiled. These 2 jars of beef were 2 out of 24 jars of beef that were processed 3 hours in the boiling water bath. They were, at the same time, 2 out of the 96 jars and cans of both beef and pork which were processed for that length of time. The spoilage in these 2 jars was shown by bacteriological tests to be due to underprocessing rather than leaks or imperfect seals.

SUMMARY

Seven hundred and seventy-nine pounds of beef and pork were canned in February 1929 and 1930 with the following variables: Canning in glass and in tin, processing in the pressure cooker and in the boiling water bath, storing at room temperature and in the basement.

The glass jars were found to make perfect seals which were maintained during the storage period. The meat canned in glass showed no spoilage attributed to leaks or imperfect seals. Due to unexplained reasons, some spoilage due to imperfect seals or leaks occurred in the meat canned in tin cans in 1929, but none occurred in the meat canned in 1930.

There was no spoilage due to underprocessing in any of the meat processed for either 45 or 60 minutes at 15 pounds pressure in the No. 2 cans or pint jars. This was also true of that processed 4 hours in the boiling water bath. However, processing canned meat in the boiling water bath is not recommended in this climate because of the possibility of poisoning from botulism.

The meat stored in the basement showed more spoilage than that stored at room temperature. Even the basement temperatures were warm during the summer.

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MAY, 1931. LOUISIANA BULLETIN No. 221.

Cotton Price-Quality Relationships In Local Markets of Louisiana

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ACKNOWLEDGMENTS

The author wishes to acknowledge indebtedness to L. D. Howell and J. S. Burgess of the Bureau of Agricultural Economics for many helpful suggestions and for having done much of the difficult work of assembling the data here shown; to M. L. Garner for assistance in the field collection of data; to Rodney Whitaker for editorial assistance; and to the ginners, warehousemen, and cotton buyers of Louisiana whose splendid cooperation made this study possible.

Cotton Price-Quality Relationships in Local Markets of Louisiana

By C. C. FARRINGTON*

To bring about the proper relationship between the farm price and the quality of cotton sold by farmers is one of the most important problems in the American cotton industry. The variation of the farm price of cotton in accordance with its quality is of vital interest to the producers individually, and to the cotton industry as a whole. This is one of the most discussed current problems, particularly among agriculturists, because it is of utmost importance in connection with the improvement of the quality of American cotton. An improvement program along this line must, of necessity, depend upon the relative profitableness of the various qualities of cotton to the grower, because profit is the most important factor in all economic activity.

When farmers are urged to adjust the quality of their production to demand, what demand is referred to? Is it mill demand or the local market demand as reflected to farmers in prices actually paid? Obviously the former is meant, but the latter is the only one in which the individual farmer is interested materially.

Most of the deterioration in the quality of the American cotton crop is usually attributed to a supposed system of "point buying" or indiscrimination on the part of local buyers with respect to prices paid to farmers for different qualities of cotton. This, in other words, is the failure of mill demand to be reflected accurately in local markets.

Deterioration in the quality of cotton produced in Louisiana and other states has occurred in spite of the fact that our Agricultural colleges, Experiment Stations, United States Department of Agriculture, Extension workers, and others interested in the welfare of our cotton growers have tried to encourage the production of better quality cotton. Improved varieties have been developed, pure seed has been distributed, the establishment of one variety communities has been encouraged, and improved cultural methods have been introduced in an effort to bring about the production of better quality cotton. Although these efforts are commendable, the results which were hoped for, have not been attained generally.

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*Employed jointly during 1928-29 by the Louisiana Experiment Station and United States Department of Agriculture, Bureau of Agricultural Economics to assist in the collection of data on which this report is based.

While these attempts were being made to improve quality, many cotton growers have claimed that it was to their economic advantage, individually, to produce short staple cotton. Arguments advanced in favor of such contention were to the effect that the short staple cottons mature more quickly and thus avoid severe boll weevil damage, are easier to pick, yield a higher percentage of lint per pound of seed cotton and usually equal or greater amounts of seed cotton per acre, and secure about the same prices as those paid for better quality cottons. The last allegation is perhaps the most significant, and it is the one to which this study is directed. It is believed that such a study is basic and fundamental to a well balanced program for the improvement either of the quality of cotton being produced or of the existing cotton marketing system.

Purpose

The purposes of this study are:

1. To determine the extent to which prices paid to farmers in local markets for cotton varied with length of staple.

2. To determine the relationship between premiums and discount for staple length in local markets and in central markets.

3. To determine the extent to which prices paid to farmers in local markets for cotton varied with grade.

4. To determine the relationship between grade differences in local and in central markets.

5. To determine the relationship between the average prices in local markets and in central markets.

6. To determine insofar as possible the factors affecting each of the above.

PROCEDURE ‡

COLLECTION OF GRADE AND STAPLE DATA

Collection and tabulation of the data for this study were supervised and financed by the Bureau of Agricultural Economics, United States Department of Agriculture and the Louisiana Agricultural Experiment Station, cooperating. The field work was carried on in connection with the estimation of the grade and staple of cotton produced in Louisiana. The grade and staple of cotton included in this study were determined from the classification by government classers of samples secured from each bale of cotton ginned at specified gins. These gins were selected in such a way that the cotton from them might represent as nearly as possible the quality of all cotton produced in the state. Approximately, fifty gins representing about 10 per cent of total ginnings were selected. Joint employees of the Bureau of Agricultural Economics and the Louisiana Agricultural Experiment Station visited the cooperating gins at frequent intervals throughout the season to see that the samples were properly secured, identified, and mailed to the regional office of the Division of Cotton Marketing, at Austin, Texas, where they were classed by a board of senior specialists in cotton classing.

COLLECTION OF PRICE DATA

Price data on which this study is based were obtained at the end of the 1928-29 ginning season from cotton buyers at ten local markets in Louisiana. These local markets were selected to represent certain type-of-buyer markets, such as commission-buyer markets, ginner-buyer markets, merchant-buyer markets, and combinations of these types. Price data were secured for as many as possible of the bales from which samples had been obtained at the

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‡The collection and tabulation of data for this study were conducted by the Division of Cotton Marketing, Bureau of Agricultural Economics in cooperation with the Louisiana Experiment Station. Acknowledgment is respectfully given to:
Division of Cotton Marketing.
Mr. A. W. Palmer, In Charge.
Dr. B. Youngblood, Principal Agricultural Economist, formerly in charge of research.
Mr. W. B. Lanham, Senior Agricultural Economist, project leader Grade and Staple Estimates.
Mr. L. D. Howell, Senior Agricultural Economist, project leader Cotton Prices Related to Quality.
Mr. John T. Egan, Senior Agricultural Economist, In charge of field work.
Louisiana Experiment Station.
Dr. C. T. Dowell, Director.
Dr. R. L. Thompson, In charge of Economic research.

cooperating gin located at each of the local markets studied. These data, obtained from the buyers' records, consisted of bale serial numbers for linking price data with samples, actual prices paid, dates of purchase, buyers' grade and staple designations if these had been recorded, and such other data as were pertinent and obtainable. At each local market studied data were obtained relative to freight rates, points of destination for cotton shipments, warehouse facilities and charges, insurance, interest and rediscount rates, weighing, sampling, and drayage charges, general marketing practices, and other pertinent information.

TABULATION OF PRICE DATA

Different price levels in central markets and the changing quality of cotton marketed in the local markets made it impossible to use average price for each quality as a measure of price-quality relationships in local markets. It might so happen that low quality cotton was marketed during a period of high prices, and high quality cotton during a period of low prices; hence, average prices for the low quality cotton would be higher than those for high quality cotton. In order to eliminate this difficulty the spread or difference between local market prices and central market prices for the same quality of cotton was employed since limited changes in price level should not affect the spread between central and local market prices, materially. In tabulating the price data, the actual price paid for a particular quality of cotton in a local market was subtracted from the central market price* for cotton of the same quality on the same day. A weighted average of these spreads for cotton of each grade and staple marketed each month in each market was calculated. In computing the premiums and discounts for staple length, the average monthly spread for ⅞ inch cotton of each grade was subtracted from the spread for each of the other staple lengths of the same grade. The average adjusted spreads thus obtained for the various staple length of each grade were combined to give a weighted average spread for each staple length of all grades. The monthly averages for each market thus computed were combined to give a seasonal average for each market.

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*Average of the quotations for the ten designated spot markets were used for the Middling ⅞ inch price and the grade differences paid in central markets. Averages of the quotations of six spot markets were used for 15/16 and 1 inch staple premiums. For staple lengths longer than 1 inch averages of the premiums quoted in New Orleans and Memphis were used. A discount of 50 points was assumed for 13/16 inch and shorter cotton.

The average adjusted spreads for each staple length indicated the extent to which the staple premiums and discounts paid in each local market varied from those quoted in central markets. By subtracting these spreads from the central market staple premiums and discounts, the local market staple premiums and discounts were obtained. In determining grade differences paid in local markets a similar procedure was employed, using middling white cotton of each staple length as a base.

CLASSIFICATION OF LOCAL COTTON MARKETS

The term local cotton market is used to designate a market place in which the predominating type of transaction is the initial sale of raw cotton by farmers. The resale of cotton by local buyers to cotton merchants is not considered as a local market function, and such sales are not included, even though the transactions were made in the local market places.

Ten local markets of Louisiana are included in this study. These markets were selected to represent as nearly as possible the various types of local markets existing in Louisiana during 1928-29. The markets are widely scattered throughout the state, and, while they may not give an accurate proportional representation of all marketing conditions in the state, it is believed that different types of markets are well represented.

Each of the markets included in this study is more or less different from each of the other markets. It has been possible, however, to classify the ten markets into two general groups, each containing five markets. One of these groups has been designated as commission and independent buyer markets. This group includes those local markets in which most or all of the cotton was bought either by buyers purchasing cotton for a central cotton merchant or firm on a commission basis or by buyers purchasing cotton independently or for their own account.

Both commission and independent buyers dealt with farmers on a cash basis. The other group has been designated as merchant and ginner-merchant buyer markets. The markets included in this group are those in which most or all of the cotton sold by the farmers was purchased or taken in on account by store-keepers or general store merchant who furnished the farmers with food, clothing, and other supplies. In some cases, the merchants or storekeepers also owned the gin at which the cotton on which price data were obtained was ginned. Much of the cotton sold in these markets was bought on a credit basis and cotton buying was practiced by the merchants as a subsidiary operation in conjunction with the management of their general merchandise stores. For the purpose of brevity, the former group will be designated hereinafter as commission markets, and the latter group as merchant markets.

COMMISSION MARKETS

In all of the commission markets the buyers purchasing cotton on commission, predominated. The commission buyers received a fee, usually $ .50 or $1.00 for each bale of cotton purchased. Usually these buyers purchased cotton directly and solely for a cotton merchant in a central market. Their purchases were made generally on the basis of limits furnished to them periodically by the merchant for whom they were buying. The limits or "basis" furnished to the commission buyers usually indicated the price for middling 7/8 inch or some other quality of cotton to be used as a base and the premiums or discounts to be made for grades and staple lengths other than the base quality.

In most cases commission buyers did not guarantee the grade, staple length, or weight of the cotton purchased. It is evident, however, that a commission buyer could not retain his position unless the grades and staples on which he purchased cotton averaged out favorably when the cotton was taken up by the central market firm.

The independent buyers, a few of whom operated in these markets, bought cotton independently, on their own account, and at their own risk. Many of these buyers, however, regularly disposed of their cotton to certain central market firms, usually at the close of each day.

The commission markets were sub-divided into two groups. One of these groups included two local markets in which the cooperating ginner or buyer directly interested in the gin company bought cotton on a commission basis. These two markets will be designated as Market A and Market B. In Market A most of the cotton on which price data were obtained, was bought by two commission buyers directly interested in the cooperating gin, and the remainder was purchased by commission buyers not interested in the cooperating gin. In Market B less than half of the cotton was bought on commission by the cooperating ginner, and over half of it was purchased by a number of commission buyers not interested in the cooperating gin. In this market there was one independent buyer and one merchant (storekeeper) buyer, each of whom bought a few bales of cotton on which price data were obtained.

The other group of commission markets includes three local markets in which the influence of ginner-buying was absent, since no cotton was purchased by ginners in these markets. Independent buyers, as well as commission buyers, operated in each of these markets. These markets shall be designated hereinafter as Market C, Market D, and Market E. One merchant, buying cotton on account, was present in each of two of these markets, but the amount of cotton bought by these merchant buyers was insignificant as compared to the amount bought by the commission and independent buyers.

MERCHANT MARKETS

In each of the merchant markets, all or practically all of the cotton on which price data were obtained was purchased by store merchants. The main object of the merchant buyer in many cases was to make collections on store credit accounts. The buying of cotton, of and by itself, may or may not have been a profitable enterprise and was often engaged in solely for the purpose of making the primary business of the merchant more profitable.

The merchant markets were divided into three divisions. One of these divisions included two local markets, designated as Markets F and G, in which all of the cotton sold at each market was purchased by one merchant who operated a large general merchandise store and the only gin in the town. In each market, the operation of the store and the gin and the buying of cotton were under the same management. Practically no competition for the buying or ginning of cotton existed in either of these markets, and they were representative of non-competitive merchant markets. In both of these markets, the cotton purchased by the store-keeper was sold periodically to the highest bidder among representatives of central market firms. These representatives were notified whenever a lot of cotton was to be offered for sale.

Another division of the merchant markets includes two markets to be called Market H and Market J, in which several storekeepers bought cotton and none of the storekeepers was directly interested in the cooperating gin. These markets were representative of competitive merchant markets, since in each market three or more merchants bought cotton throughout the season and a degree of competition seemed to exist. All of the cotton sold by farmers at these markets was bought by the merchant buyers. In most cases, the storekeepers disposed of their cotton in a manner similar to that employed by the buyers in Markets F and G.

The conditions existing in the other merchant market, Market K, were considerably different from those in the two divisions just discussed. In this particular season, most of the cotton at Market K was purchased by one general storekeeper or his agents. During a part of the season, however, a ginner-buyer operated in the market. The principal object of the ginner-buyer was to attract business to his gin, thus competing more effectively with a rival gin in which the merchant buyer was interested.

CENTRAL MARKETS

The terms "central markets" or "ten designated spot markets" referred to in this paper are spot cotton markets which have been designated by the Secretary of Agriculture, United States Department of Agriculture, as official markets for spot price quotations. Central market prices are the official spot price quotations in these markets. The ten designated spot markets are Norfolk, Augusta, Savannah, Memphis, Little Rock, Dallas, Galveston, and New Orleans.

MEASURING THE QUALITY OF COTTON ‡‡

The spinning value of cotton can be expressed in terms of grade, staple length, and character. "Grade—is a term denoting the composite of: (1) The color, lustre, and brightness of lint, (2) the nature and amount of foreign matter present in the lint, such as leaf, dust, etc., and (3) the preparation or ginning."

The determination of grade depends largely upon the ability and experience of the person classing the cotton. "For the most part, a cotton classer must rely upon his own experience and knowledge of trade practice; he must average in his mind all the factors, color, leaf, and preparation and assign to each bale a grade designation, the standard of which most nearly corresponds in intrinsic value to the bale." No hard and fast rules can be laid down for determining the grade of cotton. For example, excess of leaf may be compensated by brightness in color or cleanliness may be offset by poor preparation or any number of other combinations or variations may occur which must be evaluated by the classer.

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‡‡The quotations in this section and many of the other facts presented are taken from the United States Department of Agriculture-Department Circular 278. "The Commercial Classification of American Cotton", by A. W. Palmer.

Staple length refers to the length of fibers and in this country is designated in terms of inches and fractions of an inch, usually thirty-seconds and multiples thereof. The staple length of a sample of cotton may be determined quite accurately by the actual measurement of typical fibers. The securing of representative or typical fibers is a process involving much skill, however, and may give rise to considerable difficulty and inconsistency. Few commercial classers take the time to pull out the fibers and measure them. The length of the sample being estimated rapidly from the "break" and "drag" of the cotton in their hands. Thus, it is evident that the "human element" is a factor of considerable importance in the determination of staple length as well as of grade. Furthermore, the apparent staple length of cotton may be influenced considerably by atmospheric conditions and by the looseness or compactness of the sample.

"Character" is almost equal in importance to grade and staple in determining quality and is probably the least understood of the three. Character has to do with the strength, body, uniformity, and smoothness of the fibers. There is as yet no official standard by which to measure character, and the classer must judge it by the "break" and "drag" and the feeling of the fibers in his hands, guided only by his training and experience.

From the above discussion, it is evident that the classing of cotton is a very intricate process in which human judgment and experience are of primary importance, and physical factors in the classing room, such as light, humidity, and temperature are important determinants. It is not at all surprising, that cotton classers who differ considerably in training and experience, and even those with similar training and experience often fail to agree as to the grade and staple designation of an identical sample. It is possible, however, that classers with comparable training and experience, working under similar conditions of light and humidity may attain a high degree of consistency in grade and staple designations.

Cotton, like many other commodities, does not lend itself to classification into definite class intervals. In a number of samples of cotton all placed in the same grade or staple length, the samples would vary considerably. Some would be barely good enough to be included in the grade or length designated, while others would be almost good enough to be included in a higher grade or length. In spite of these difficulties, however, there is a tendency for these "errors of observation" to compensate for each other, and to "average out" when a number of samples are concerned, unless a consistent bias in one way or another exists.

The above discussion emphasizes the inconsistencies which may arise in the classing of cotton, and hence the importance of having this factor kept as nearly constant as possible in all economic studies involving quality designations. It also recognizes bias and inconsistencies which may be prevalent in the classification of cotton included in this study. It should be noted, however, that the classification of all the cotton included in this analysis was determined by a board of senior specialists in cotton classing, licensed and employed by the United States Department of Agriculture. The classing was done in a room specially designed for cotton classing, but without controlled or artificial light and humidity.

Prices received by farmers from local buyers for various qualities of cotton were based upon the classification by the purchasers, of a sample secured from one or both sides of the bale. The buyer may or may not have had training and experience in cotton classing, may or may not have been acquainted with the official government standards, and may have classed the cotton either in a specially designed cotton classing room, or in a room not adapted to cotton classing, or out of doors.

The factors in the determination of quality of special significance to this study are presented briefly in outline form below:

Local market prices were collected for cotton of various qualities—based on quality:

(1) As represented by samples secured from one or both sides of bales.

(2) As determined by local buyers of different training and experience.

    (a) In local markets of Louisiana with varying condition of light, moisture, temperature, etc.

        (b) Perhaps according to commercial standards or types which may differ considerably from official standards.

In this study a comparison has been made of these local market prices for cotton of various qualities—based on quality:

(1) As represented by samples secured at the gin, usually from the press box.

(2) As classed by senior specialists in cotton classing, licensed and employed by the United States Department of Agriculture.

    (a) At Austin, Texas, in a room designed for cotton classing, but without controlled light and humidity.

    (b) According to the official cotton standards of the United States as of August 1, 1928 to July 31, 1929.

QUALITY OF COTTON IN LOUISIANA

Government estimates of the quality of cotton ginned in Louisiana during the 1928-29 season are available. These figures indicate that about 13 per cent of all cotton ginned in the state was $\frac{13}{16}$ of an inch or less in staple length, 29.9 per cent was $\frac{7}{8}$ of an inch, 26.2 per cent was $\frac{15}{16}$ inch, 18.4 per cent was 1 inch, 7.4 per cent was $1\frac{1}{16}$ inches, while only 5.2 per cent was $1\frac{1}{8}$ inches or longer. Grade estimates were somewhat more favorable since 83.25 per cent of the cotton ginned in Louisiana in 1928-29 was middling or better, and only 16.75 was below middling. Of the total crop, 13.74 per cent was included in those grade and staple lengths which are untenderable on futures contracts according to Section 5, United States Cotton Futures Act. These figures are given in detail in Table 1.

The average staple length of the cotton included in this study was greater than that of the entire Louisiana crop. Of the price study bales only 6 per cent was of less than $\frac{7}{8}$ inch staple, 20.8 per cent was $\frac{7}{8}$ inch, 27.5 per cent was $\frac{15}{16}$ inch, 26.2 per cent was 1 inch, 12.0 per cent was $1\frac{1}{16}$ inches, and 7.5 per cent was $1\frac{1}{8}$ inches or longer in length of staple. Combining the above totals, 54.3 per cent of the price study cotton had a staple length of less than 1 inch, as compared to 69.1 per cent of all cotton ginned in the state in 1928-29.

TABLE 1

The grade and staple length of cotton ginned in the State of Louisiana—Crop of 1928*

Grade	Total		13-16″ and less		7-8″		15-16″ and 31-32″		1″ and 1 1-32″		1 1-16″ and 1 3-32″		1 1-8″ and longer	
	Bales	%	Bales	%	Bales	%	Bales	%	Bales	%	Bales	%	Bales	%
Total	685,036	100.0	89,075	13.00	204,813	29.90	179,498	26.20	125,766	18.36	50,428	7.36	35,456	5.18
White and Extra White	659,929	96.34	84,055	12.27	197,625	28.85	172,814	25.22	121,514	17.74	49,152	7.18	34,769	5.08
M. F.	105	.02	46	†					20	†	28	†	11	†
S. G. M.	2,316	.34	304	.04	782	.11	576	.08	523	.08	131	.02		
G. M.	105,583	15.41	15,206	2.22	33,570	4.90	26,037	3.80	19,259	2.81	7,013	1.02	4,498	.66
S. M.	283,977	41.45	34,949	5.10	93,226	13.61	75,422	11.01	49,302	7.20	18,806	2.75	12,272	1.79
M.	177,109	25.86	19,444	2.84	50,189	7.33	48,015	7.01	34,969	5.10	13,920	2.03	10,572	1.54
S. L. M.	73,188	10.68	11,530	1.68	16,732	2.44	17,821	2.60	13,835	2.02	7,526	1.10	5,744	.85
L. M.	14,968	2.19	2,278	.33	2,715	.40	3,952	.58	3,089	.45	1,545	.23	1,389	.20
S. G. O. ‡	2,593	.38	276	.04	393	.06	952	.14	506	.07	183	.03	283	.04
G. O. ‡	90	.01	22	†	18	†	39	†	11	†				
Spotted	23,713	3.46	4,895	.71	6,918	1.01	6,432	.94	3,999	.58	1,120	.16	349	.05
G. M.	3,501	.51	1,054	.15	1,092	.16	714	.10	535	.08	87	.01	19	†
S. M.	10,327	1.51	1,701	.25	2,924	.43	2,741	.40	2,151	.31	633	.09	177	.03
M.	7,837	1.14	1,674	.24	2,514	.37	2,202	.32	1,020	.15	327	.05	100	.01
S. L. M. ‡	1,616	.24	316	.05	348	.05	602	.09	244	.04	53	†	53	†
L. M. ‡	432	.06	150	.02	40	†	173	.03	49	†	20	†		
Colored	511	.07	69	†	219	.03	114	.02	73	.01	27	†	9	†
Tenderable	216	.03	19	†	96	.01	46	†	37	†	9	†	9	†
Untend. ‡	295	.04	50	†	123	.02	68	†	36	†	18	†		
No Grade ‡	883	.13	56	†	51	†	138	.02	180	.03	129	.02	329	.05

*Compiled from a preliminary report of the United States Department of Agriculture, Bureau of Agricultural Economics, in cooperation with the Louisiana State Experiment Station, issued April 19, 1929.

†Less than 0.1 per cent.

‡Untenderable according to Section 5, U. S. Cotton Futures Act.

The grade of the price study cotton was very similar to the grade of the total crop, however, slightly more of the former was of the lower grades. These data are given more in detail in Table 2.

Differences in the grade and staple of the price study cotton and the entire crop does not invalidate the usefulness of the price data. It is fortunate, in fact, that data were obtained on a relatively greater proportion of long staple and low grade cotton, because otherwise, the sample of these qualities would have been less adequate. On the other hand, a few bales more or less of the common qualities had little effect on the representativeness of the sample for these qualities.

TABLE 2

Grade and staple length of cotton included in the Louisiana local market price study*—Crop of 1928

Grade	Total		13-16" and less		7-8"		15-16" and 31-32"		1" and 1 1-32"		1 1-16" and 1 3-32"		1 1-8" and longer	
	Bales	%	Bales	%	Bales	%	Bales	%	Bales	%	Bales	%	Bales	%
Total	6,846	100.0	408	6.0	1,423	20.8	1,881	27.5	1,793	26.2	825	12.0	516	7.5
White and Extra White	6,453	94.3	369	5.4	1,340	19.6	1,742	25.9	1,695	24.8	795	....	512	7.5
M. F.	....	....	....	....	....	....	....	....	....	....	....	....	....	....
S. G. M.	7	0.1	....	....	2	†	1	†	1	†	3	†	....	....
G. M.	859	12.5	62	0.9	169	2.5	211	3.1	244	3.6	107	1.6	66	1.0
S. M.	2,606	38.1	171	2.5	635	9.3	661	9.7	637	9.3	281	4.1	221	3.2
M.	2,069	30.2	92	1.3	410	6.0	623	9.1	563	8.2	245	3.6	136	2.0
S. L. M.	751	11.0	35	0.5	101	1.5	201	2.9	205	3.0	136	2.0	73	1.1
L. M.	146	2.1	8	0.1	21	0.3	41	0.6	42	0.6	22	0.3	12	0.2
S. G. O. ‡	13	0.2	1	†	1	†	3	†	3	†	1	†	4	†
G. O. ‡	2	†	....	....	1	†	1	†	....	....	....	....	....	....
Spotted	393	5.7	39	0.6	83	1.2	139	2.0	98	1.4	30	0.4	4	†
G. M.	79	1.2	14	0.2	21	0.3	23	0.3	18	0.3	3	†	....	....
S. M.	199	2.9	14	0.2	37	0.5	78	1.1	52	0.7	15	0.2	3	†
M.	93	1.3	9	0.1	23	0.3	29	0.4	21	0.3	10	0.1	1	†
S. L. M. ‡	21	0.3	2	†	2	†	9	0.1	7	0.1	1	†	....	....
L. M. ‡	....	....	....	....	....	....	....	....	....	....	1	†	....	....

*Single bale purchases—"Round lot" purchases are excluded.
†Less than 0.1 per cent.
‡Untenderable according to Section 5—U. S. Cotton Futures Act.

PREMIUMS AND DISCOUNTS FOR STAPLE LENGTH

The differences in prices received by farmers in ten local markets of Louisiana during the 1928-29 season for differences in staple length as determined by government classers were very small on an average. Premiums and discounts for staple length received by farmers averaged only a small proportion of the premiums and discounts for staple length paid in central markets. This comparison of staple premiums and discounts for lengths shorter and longer than ⅞ inch is shown in Fig. 1. The central market discount for $\frac{13}{16}$ inch cotton was $2.50 per 500 pound bale, whereas the local market discount averaged $.30 or only 12 per cent of that in the central markets. A premium of $1.35 per bale was paid in central markets for $\frac{15}{16}$ inch cotton, while in local markets the average premium was only $ .10 or slightly more than 7 per cent of the central market premium. Relatively greater premiums were paid for 1 inch cotton, the average premium in local markets being $1.25 or 31.5 per cent of the central market premium of $4.00 per bale. The staples longer than 1 inch were recognized on an average in the local markets to about the same or slightly greater extent than was 1 inch cotton.

It is significant, however, that the three shorter staple lengths ($\frac{13}{16}$, ⅞, and $\frac{15}{16}$) constitute about 70 per cent of all the cotton ginned in Louisiana during the 1928-29 cotton season and on the average all of it sold for approximately the same price. Practically no premium was paid for $\frac{15}{16}$ inch cotton and very little discount was made for $\frac{13}{16}$ inch cotton.

A very marked contrast between the different type markets may be noted by comparison of staple differences in central spot markets with those in the five commission markets and the five merchant markets (Fig. 2). Average prices paid in commission markets reflected to a considerable degree the central market differences for staple length as designated by the government classers, but the prices paid in merchant markets indicate no recognition of staple length in these markets. The average price paid for ⅞ inch cotton in the five merchant markets was higher than for any other staple length. Thirteen-sixteenths inch is the only staple length which was discounted in all three types of markets, the average discount per bale being $2.50 in the central markets, $ .45 in the commission markets and $ .20 in the merchant markets.

Fig. 1--Average premiums and discounts for staple length in local markets of Louisiana and in central markets, 1928-29

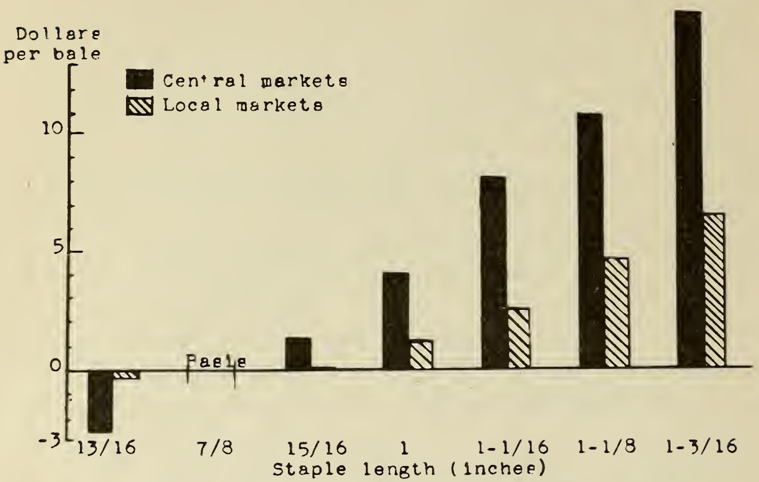
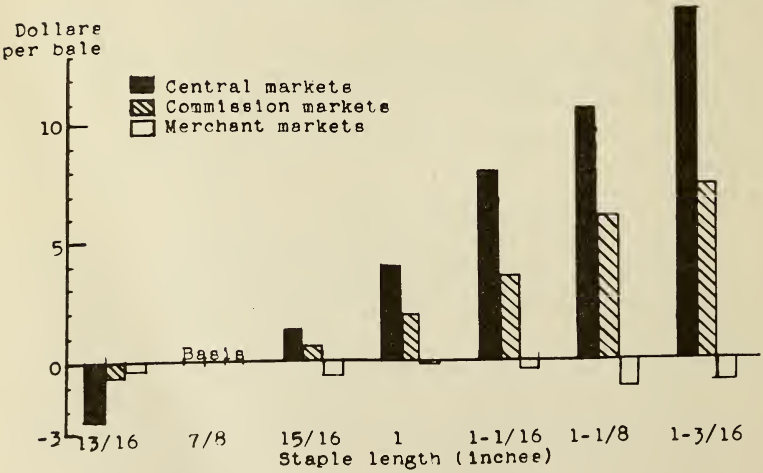


Fig.2--Average premiums and discounts for staple length in local commission, and local merchant markets of Louisiana and in central markets, 1928-29



Premiums for each staple length longer than ⅞ inch in the commission buyer markets were approximately 50 per cent of those in the central markets. This clearly indicates that although staple length was not recognized in some markets, it was recognized to a considerable degree in others.

Average premiums and discounts for staple differed even more widely in the various sub-types of local markets of Louisiana. Average premiums for staple length longer than $\frac{7}{8}$ inch were considerably greater in non-ginner commission buyer markets, C, D, and E, than in any other type of local market studied. (Fig. 3). Premiums in this type of market averaged $ .90 per bale of 500 pounds for $\frac{15}{16}$ inch cotton $2.85 for 1 inch, $4.20 for $1\frac{1}{16}$ inches, $6.40 for $1\frac{1}{8}$ inches and $7.30 for $1\frac{3}{16}$ inches. The premiums for staple length in the ginner-commission-buyer markets, A and B, were considerably less than those of the above markets. Premiums paid in the ginner-commission-buyer markets, however, were greater than those of any of the merchant market types.

Competitive merchant markets, H and J, were the only merchant markets in which even small staple premiums were paid. Average premiums paid in these markets expressed in dollars per 500 pound bale were as follows: $\frac{15}{16}$ inch $ .20, 1 inch $ .35 and $1\frac{1}{16}$ inches $1.40. In the other two types of merchant markets, the average prices paid for each staple length longer than $\frac{7}{8}$ inch were lower than those paid for $\frac{7}{8}$ inch cotton of the same grade. In the non-competitive ginner-merchant markets F, and G, the farmers actually received an average of $ .85 less for $\frac{15}{16}$ inch cotton, $1.05 less for $1\frac{1}{8}$ inch cotton, and $ .80 less for $1\frac{3}{16}$ inch cotton than they did for $\frac{7}{8}$ inch cotton. Smaller discounts were made for 1 inch and $1\frac{1}{16}$ inch cotton, but these staple lengths also brought lower average prices than $\frac{7}{8}$ inch cotton.

In the ginner and merchant market K (which was largely non-competitive during most of the season) the prices received by farmers averaged $ .35 per bale less for $\frac{15}{16}$ inch cotton and $1.65 less for 1 inch cotton than for $\frac{7}{8}$ inch cotton.

Slightly lower average prices were received by farmers for $\frac{13}{16}$ inch cotton than for $\frac{7}{8}$ inch cotton in each type of market. The average discount for $\frac{13}{16}$ inch cotton under $\frac{7}{8}$ inch cotton was $ .90 in the ginner and merchant market, $ .60 in the non-ginner commission type markets and $ .30, $ .15, and $ .10 in the other three types of markets, respectively.

The average premiums received by farmers in the non-ginner commission markets compare very favorably with those paid in central markets. On the average, about $\frac{2}{3}$ of the central market premiums for staple length longer than $\frac{7}{8}$ inch were reflected in the prices received by farmers in the non-ginner commission mar-

Fig. 3--Average premiums and discounts for staple length in local ginner and non-ginner commission markets of Louisiana and in central markets, 1928-29

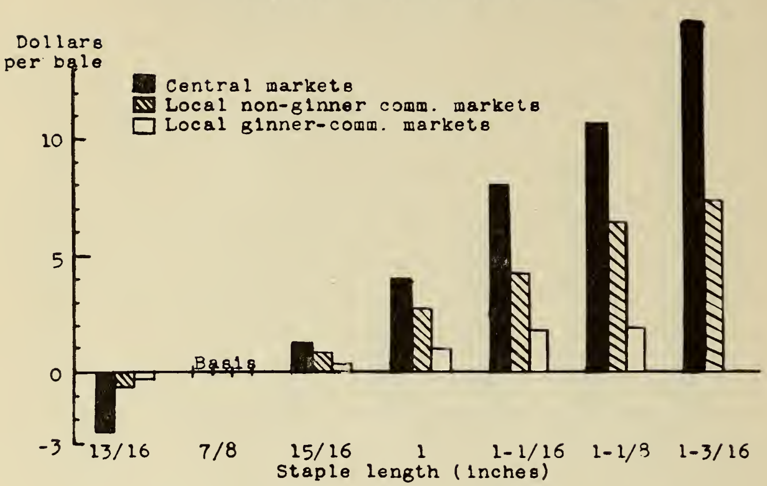
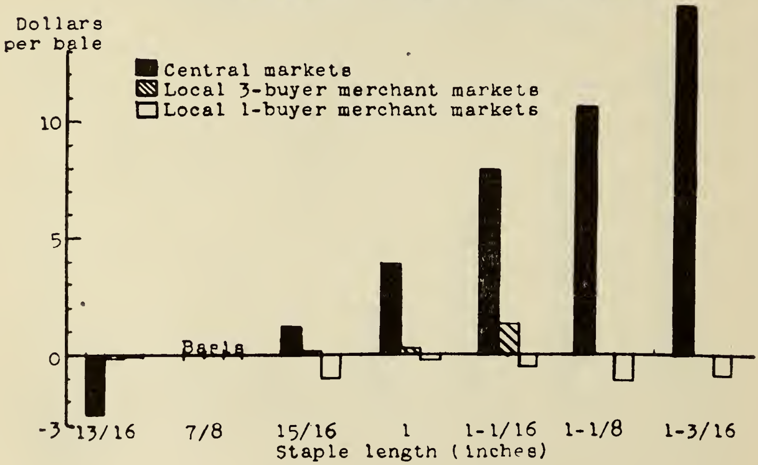


Fig. 4--Average premiums and discounts for staple length in local competitive and non-competitive merchant markets of Louisiana and in central markets, 1928-29



kets. It may be noted that the difference between premiums paid in central markets and premiums paid in this type of local market for staple length tends to increase as the staple length becomes longer and the number of bales less, as might be expected with the increase in the risk involved, and in the cost of assembling.

The premiums received by farmers for staple lengths longer than 7/8 inch in the ginner commission markets were on an average about one-fourth of those quoted in central markets. Only about one-fifth of the central market premiums were reflected in the prices received by farmers in the competitive merchant markets.

Discounts received by farmers for staple length longer than 7/8 inch in the non-competitive merchant and ginner merchant type of markets as compared to premiums quoted in the central markets, indicate a deplorable discrepancy for which there seems to be little justification. That all of the quoted central market premiums for staple length should always be reflected in prices paid in local markets could hardly be expected, but a difference of $11.75 in the average price paid for 1 1/8 inch cotton in certain local markets and in central markets in relation to the prices paid for 7/8 inch cotton seems unreasonable.

This section is devoted principally to a study of premiums and discounts for staple lengths other than 7/8 of an inch as measured from the average prices for 7/8 inch cotton, but in this connection the average prices for 7/8 inch cotton in the various markets are worth noting. (Table 3). The averaged adjusted base price for all of the local markets was $91.95 per 500 pound bale as compared to $92.20 per bale, the average price of Middling 7/8 inch cotton in New Orleans. This average base price for local markets is higher relative to the New Orleans price than would normally be expected because freight and compressing are the only changes for which allowance has been made. This relatively high average price for 7/8 inch cotton probably indicates that local buyers paid prices relatively too high for cotton called 7/8 inch by the government classers, and relatively too low for cotton designated as longer staple.

The highest adjusted price for 7/8 inch cotton was paid in Market E, and the lowest, was paid in Market D. When the markets were classified by types, the average adjusted price for 7/8 inch cotton was highest in the non-ginner commission markets, second highest in the ginner commission markets, third highest in the competitive merchant markets, and lowest in non-competitive merchant markets. Merchant markets, as a whole, show lower average adjusted prices for 7/8 inch cotton as well as considerably lower premiums for the staple lengths longer than 7/8 of an inch, than the commission markets.

In summarizing the staple premium and discount data it was found that the extent to which central market premiums and discounts for staple lengths other than ⅞ inch were reflected in the local markets varied from 72 per cent in Market D to a minus 47 per cent in Market K. The negative percentage shown for Market K and two of the other merchant markets indicates that farmers actually received a discount on the cotton designated as of the staple lengths longer than ⅞ inch by government classers, while the central markets show considerable premiums for these staple lengths. These data are summarized and given in detail for all markets in Table 3.

Each of the non-ginner commission markets had a higher proportional reflection of central market price differences for staple length than any of the other markets. The average reflection for these three markets was 59.0 per cent. Central market price differences were reflected to a greater extent in each of the other two commission markets than in any of the merchant markets. The average percentage of central market differences for staple length paid to farmers in these two ginner-commission markets was approximately 25 per cent. Central market staple premiums and discounts were received by farmers to the extent of about 50 per cent in all commission markets combined.

Competitive merchant markets were the only merchant markets showing any positive reflection of central market price differences for staple length. The average for these markets is about 10 per cent. The average price difference for staple lengths other than ⅞ inch was a discount in Market J, because much of the cotton sold in this market was $\frac{13}{16}$ inch and less. The average discount paid in this market averaged about 6 per cent of the discount based on central market price differences for staple length.

The discount for $\frac{13}{16}$ inch cotton was the only central market price difference for staple length which was reflected positively in the other three merchant markets. Aggregate discounts received by farmers in Market F were over 30 per cent as great as the total premiums based on central market price differences for staple lengths. The corresponding percentage for Market G was 8.1 per cent and for Local Market K, as previously mentioned was 46.7 per cent. The average proportional reflection of central market price differences for staple length in all merchant markets was minus 9.8 per cent as compared to plus 48.4 per cent in commission markets. The average for all markets was plus 31.1 per cent.

TABLE 3

Average adjusted prices for ⅞ inch cotton, average premiums and discounts for staple length, and average percentage of central market staple premiums and discounts paid, in local markets of Louisiana, and in central markets, 1928-29

Market	Average Base Price*	Premiums and discounts †							Percentage of central market
		Staple Length (inches)							
		13-16 and less	7-8	15-16	1 and 1 1-32	1 1-16 and 1 3-32	1 1-8 and 1 5-32	1 3-16 and 1 7-32	All lengths
Commission	Dollars‡	Dollars‡	Base	Dollars‡	Dollars‡	Dollars‡	Dollars‡	Dollars‡	Per Cent
Ginner									
Market A	93.05	—.30	0	.15	.85	2.95	1.35	....	20.8
Market B	91.25	—.15	0	.60	1.15	1.35	2.35	....	26.9
Average	92.5	—.30	0	.40	1.05	1.80	1.95	....	24.6
Non-Ginner									
Market C	93.20	—.70	0	.90	1.15	.15	5.50	....	39.5
Market D	90.10	1.85	0	2.50	4.55	5.60	7.10	7.25	72.2
Market E	94.05	—.20	0	.55	2.20	2.30	3.25	8.65	40.5
Average	92.60	—.60	0	.90	2.85	4.20	6.40	7.30	59.0
All	92.35	—.50	0	.65	1.95	3.55	6.00	7.30	48.4
Merchant									
Non-competitive									
Market F	90.60	—.25	0	—1.90	—.75	—.50	—1.05	—1.95	30.6
Market G	91.50	—.10	0	—.55	—.05	—.35	—1.05	.10	—8.1
Average	91.35	—.10	0	.85	—.15	—.40	—1.05	.80	—12.2
Competitive									
Market H	92.05	—.20	0	.25	0	....	....	....	13.9
Market J	90.75	—.15	0	—.10	.85	1.40	....	....	5.9
Average	91.40	—.15	0	.20	.35	1.40	....	....	9.2
Market K	91.80	—.90	0	—.35	—1.55	....	....	....	—46.7
All	91.40	—.20	0	—.60	—.15	—.35	—1.05	—.80	—9.8
All Local	91.95	—.30	0	.15	1.25	2.50	4.65	6.30	31.1
Central	92.20	—2.50	0	1.35	4.00	8.00	10.70	15.00	100.0

*The local market prices are the average prices for ⅞ inch cotton adjusted for changes in price level by means of the weighted average spread between local market and New Orleans spot market prices and for differences in location by adding to the local market prices the freight and compressing charges from the local market to New Orleans. The central market price is an average of the monthly official quotations for the New Orleans spot market. All base prices are weighted by the number of bales included in this study for each month of the marketing season.

†Basis ⅞ inch cotton equals 0—Minus (—) indicates a discount.

‡Dollars per 500 pound bale.

TABLE 4

Number of bales on which the averages shown in Table 3 are based

Market	Base Price	Staple Length (Inches)						
		13-16 and less	7-8 and 29-32	15-16 and 31-32	1 and 1 1-32	1 1-16 and 1 3-32	1 1-8 and 1 5-32	1 3-16 and 1 7-32
		Bales	Bales	Bales	Bales	Bales	Bales	Bales
Ginner-commission								
Market A	593	40	201	286	215	41	11	....
Market B	714	6	121	289	358	103	16	....
Average	1307	46	322	575	573	144	27	....
Non-ginner commission								
Market C	231	67	156	118	43	2	1	....
Market D	....	2	22	72	184	225	227	63
Market E	878	8	123	304	351	161	51	3
Average	1677	77	301	494	578	388	279	66
All commission	2984	123	623	1069	1151	532	306	66
Non-competitive merchant								
Market F	1249	8	68	107	80	32	18	4
Market G	1152	60	262	422	443	169	55	5
Average	1401	68	330	529	523	201	73	9
Competitive merchant								
Market H	148	32	219	112	4	....	....	....
Market J	148	121	129	22	3	2	....	....
Average	296	153	348	134	7	2	....	....
Merchant and ginner								
Market K	81	23	90	53	6	....	....	....
All merchant	1778	244	768	716	536	203	73	9
All local markets	4762	367	1391	1785	1687	735	379	75

GRADE DIFFERENCES

Grade differences were received by farmers in local markets to a slightly greater proportional extent than were staple premiums and discounts. Less than half of the central market premiums and discounts for grade, however, were received by the farmers in the ten markets studied.

Farmers in local markets received an average premium of 60 cents per bale for Strict Middling cotton, while the average premium for this grade in central markets was $1.25 or slightly over twice the premium in local markets. The average premium for Good Middling cotton in the local markets was 60 cents, the same as that for Strict Middling, or only 30 per cent of the average premium of $2.00 per bale quoted in central markets. An average premium of $1.20 was received by farmers on five bales of Strict Good Middling in the local markets as compared to $2.95 in central markets.

The average discount on Strict Low Middling cotton in local markets was $1.20 or 33 per cent of the $3.60 discount in central markets. The average discount on Low Middling cotton in local markets was only $1.30 or 20 per cent of the discount in central markets. On 10 bales of Strict Good Ordinary cotton sold in local markets, the average discount was $1.45 or only 15 per cent of the $9.85 central market discount. These differences are presented in detail in Fig. 5.

Fig. 5--Average grade differences in local markets of Louisiana and in central markets, 1928-29

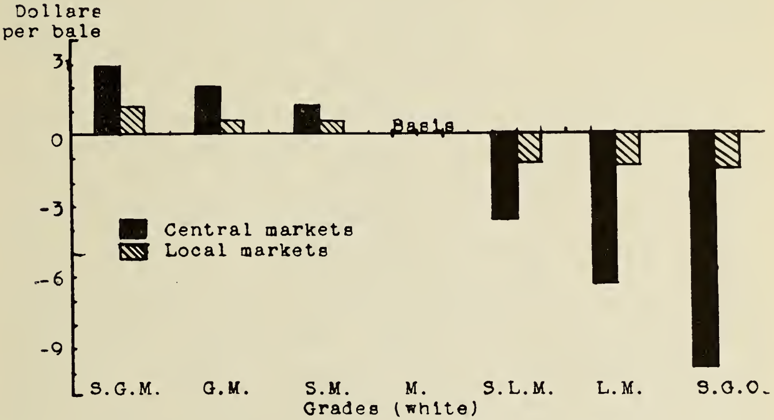
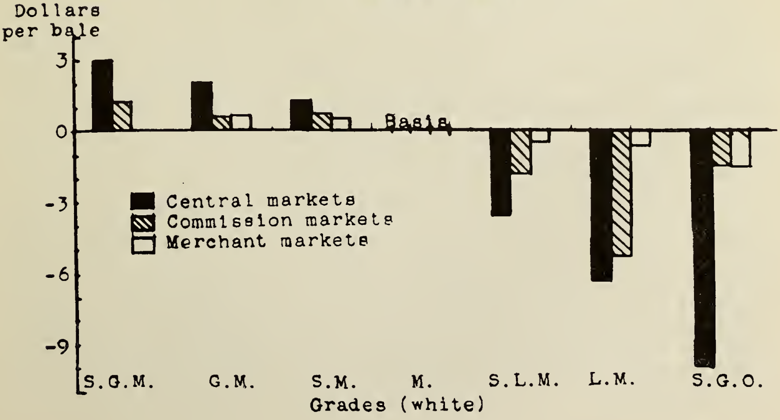


Fig. 6--Average grade differences in local commission and merchant markets of Louisiana and in central markets, 1928-29



It is often contended that very small premiums, if any, are paid in local markets for grades above Middling, while grades below Middling are severely penalized. This study, however, does not verify this contention. It is obvious that, although the farmers received only part of the central market premiums for grades better than Middling, the discounts for low grades in local markets were not nearly so large as in central markets. In fact, local buyers discounted the lower grades relatively less than they paid central market premiums for the better grades. Specifically, premiums paid by local buyers on 3,380 bales of better than Middling cotton were 42 per cent of the premiums prevailing in central markets, whereas, the total discounts in the local markets on 932 bales of cotton of the grades below Middling were only 30 per cent of the quoted central market discounts.

The above analysis emphasizes the fact that an adjustment of local market differences more nearly in line with central market differences must involve the increasing of the discounts on lower grades, as well as increasing the premiums on the higher grades.

The various types of markets differed considerably in the amount of grade differences paid, but the type of market seems to have been less significant with respect to grade differences than to staple premiums and discounts. The average premiums for Strict Middling cotton were $ .35 per bale in the five merchant markets and $ .70 in the five commission markets. On the other hand, however, buyers paid an average premium of $ .85 per bale in the merchant markets, and only $ .55 in the commission buyer markets for Good Middling cotton.

Average discounts for Strict Low Middling cotton were $1.80 in commission buyer markets, and only $ .45 in merchant markets, while discounts for Low Middling cotton were $5.30 and $ .60, respectively. Average discounts of $1.40 and $1.45 were received by farmers in the commission buyer markets and the merchant market, respectively, for Strict Good Ordinary cotton.

Very little difference was apparent in the grade differences received by farmers in the ginner commission and in the non-ginner commission buyer markets. The average premium received by farmers for Strict Middling cotton was $ .60 in the ginner commission markets, and $ .75 in the non-ginner commission markets. For Good Middling cotton the farmers received an average premium of $ .75 per bale in the ginner commission markets, and only $ .40 in the non-ginner commission markets. It may be noted that the average premium for Good Middling cotton in the non-ginner commission markets was $ .35 per bale less than that for Strict Middling; while in the central markets the average premium for Good Middling cotton was $ .75 per bale more than for Strict Middling. Why such a condition prevailed is difficult to explain. Each of the three markets included in this type showed the same tendency in this respect.

Discounts on Strict Low Middling and Low Middling in both types of commission markets were more nearly in line with central market discounts than were the premiums for the higher grades. These discounts were $1.85 and $1.80 for Strict Low Middling, and $4.65 and $6.15 for Low Middling in the ginner and non-ginner commission markets, respectively.

Considerable variation existed in grade differences received by farmers in the various merchant markets. Average premiums and discounts for grades higher and lower than Middling were greater for every grade in the competitive merchant markets than in either of the other two types of merchant markets. Grade differences received by farmers in the competitive merchant markets were in general about the same as those received in the commission buyer markets. Grade premiums for Strict Middling and Good Middling cotton in the non-competitive types of merchant markets were negligible. Discounts for grades lower than Middling averaged approximately 10 per cent of the corresponding central market discounts in these markets. Tendencies in premiums and discounts for spotted cotton agree in general with those for white cotton.

Summarizing this analysis of grade differences in local markets, it is evident that central market grade differences were reflected to some extent in all local markets. The extent to which these differences were reflected, however, varied considerably between the various markets. The price differences for grade received by farmers were 47.4 per cent and 41.9 per cent of the corresponding central market differences in Markets A and B, respectively. While in Markets C, D, and E, the corresponding percentages were 1.9, 55.1 and 52.0, respectively. About 45 per cent of the grade premiums and discounts quoted in the central markets were reflected in the five commission markets combined.

Central market grade differences were reflected to a considerably less extent in the merchant markets, as a whole, than in the commission markets, although the percentage for one of the competitive merchant markets was higher than for any of the commission markets. Grade differences in Markets F and G averaged 37.2 and 9.6 per cent, respectively, of the central market premiums and discounts for grades higher and lower than Middling. Corresponding percentages for Markets H, J, and K were 39.7, 73.5, and 6.6, respectively. The average percentage reflection of central market grade differences in all merchant markets was 19.0 as compared to 44.7 for the commission markets. About one-third of the central market grade differences were reflected in the prices received by farmers in all local markets combined.

TABLE 5

Average deviations per bale in local and central market prices for grades other than Middling from the price of Middling cotton in local markets of Louisiana, 1928-29

Market	Grade (White)						
	Strict Good Middling	Good Middling	Strict Middling	Middling	Strict Low Middling	Low Middling	Strict Good Ordinary
	$'s	$'s	$'s	Base	$'s	$'s	$'s
Ginner-commission							
Market A	....	.85	.50	0	—1.70	—5.25	....
Market B	—.20	.60	.65	0	—2.00	—4.40	—3.60
Average	—.20	.75	.60	0	—1.85	—4.65	—3.60
Non-ginner commission							
Market C	....	.30	.20	0	—.80	....	....
Market D	6.70	.55	.75	0	—2.00	—6.15	....
Market E	....	.50	1.05	0	—1.55	—6.15	3.05
Average	6.70	.40	.75	0	—1.80	—6.15	3.05
All commission	1.20	.55	.70	0	—1.80	—5.30	—1.40
Non-competitive merchant							
Market F	....	—1.50	.30	0	—1.35	....	....
Market G	....	.20	.10	0	—.35	—.60	—1.45
Average	....	.10	.15	0	—.40	—.60	—1.45
Competitive merchant							
Market H	....	.50	.55	0	—.10	....	....
Market J	....	1.40	.90	0	—5.50	....	....
Average	....	1.00	.65	0	—1.65	....	....
Merchant and ginner							
Market K	....	.95	.05	0	—.95	....	....
All merchant	....	.85	.35	0	—.45	—.60	—1.45
All local markets	1.20	.60	.55	0	—1.20	—1.30	—1.45
Central markets	2.95	2.00	1.25	0	—3.60	—6.35	—9.85

The minus (—) sign indicates discounts or lower prices than for Middling.

TABLE 6

Number of bales on which the averages shown in Table 6 are based

Market	Grade (White)						
	Strict Good Middling	Good Middling	Strict Middling	Middling	Strict Low Middling	Low Middling	Strict Good Ordinary
	Bales	Bales	Bales	Bales	Bales	Bales	Bales
Ginner-commission							
Market A	....	97	315	333	46	3	....
Market B	4	102	354	195	59	8	2
Total	4	199	669	528	105	11	2
Non-ginner commission							
Market C	....	65	193	101	8	....	....
Market D	1	95	290	226	177	5	....
Market E	....	217	369	243	96	3	1
Total	1	377	852	570	281	8	1
All commission	5	576	1521	1098	386	19	3
Non-competitive merchant							
Market F	....	2	85	166	12	....	....
Market G	....	29	340	556	273	110	7
Total	....	31	425	722	285	110	7
Competitive merchant							
Market H	....	62	225	57	5	....	....
Market J	....	67	109	41	2	....	....
Total	....	129	334	98	7	....	....
Merchant and ginner							
Market K	....	7	94	50	6	....	....
All merchant	....	167	853	870	298	110	7
All local markets	5	743	2374	1968	684	129	10

TABLE 7

Average deviation in local and central markets prices of Spotted grades from the price of Middling White cotton and the number of bales on which average deviations were based in local markets of Louisiana, 1928-29

Market	Average Deviation				Number of Bales			
	Grade (Spotted)				Grade (Spotted)			
	Good Middling	Strict Middling	Middling	Strict Low Middling	Good Middling	Strict Middling	Middling	Strict Low Middling
	Dollars per bale	Dollars per bale	Dollars per bale	Dollars per bale	Bales	Bales	Bales	Bales
Commission								
Ginner								
Market A	1.40	.40	—3.20	—4.90	21	23	2	2
Market B	.55	.05	.75	1.90	24	53	14	3
Average	.95	.15	.25	—.80	45	76	16	5
Non-ginner commission								
Market C	—2.50	—2.80	....	7.60	1	3	....	1
Market D	....	....	2.30	—17.10	....	....	1	1
Average	—2.50	—2.80	2.30	—4.75	1	3	1	2
All commission	.85	.05	.35	—1.95	46	79	17	7
Merchant Non-competitive								
Market F	—.25	.25	—1.90	—.05	6	46	21	1
Market G	—.65	—.05	—.80	—.95	20	50	48	12
Average	—.55	.10	—1.15	—.85	26	96	69	13
Competitive Merchant								
Market H	.25	1.00	—6.15	....	2	4	2	....
Market J	—.65	1.40	....	....	1	2	....	....
Average	—.05	1.15	—6.15	....	3	6	2	....
Merchant and ginner								
Market K	......	—.75	—1.15	....	....	2	1	....
All merchant	—.50	.15	—1.25	—.85	29	104	72	13
All local markets	.35	.10	—.95	—1.20	75	183	89	20
Central markets	1.15	.15	—3.40	—6.30	....	....	....	....

Minus (—) indicates a discount or lower price than for Middling white cotton.

SPREAD BETWEEN CENTRAL AND LOCAL MARKET PRICES

Considerable difference or spread naturally exists between central and local market prices. One factor which influences the amount of this spread is carrying charges from local markets to central markets. An adjusted spread between these markets was computed by subtracting freight and compressing charges incurred between each local market and New Orleans from the total spread between prices paid in each local market and average prices for the same qualities of cotton in central markets. This process eliminated as nearly as possible the influence of differences in location on the spread between central and local market prices.

The adjusted spread between central market prices and local market prices during the season averaged $2.20 per bale for all markets studied. This spread for the local commission markets was $1.65 per bale as compared to $2.95 for the merchant markets or a difference of $1.30. Among the commission markets the average adjusted spread was $ .60 per bale less in the non-ginner markets than in the ginner markets. Of the two ginner markets, however, Market A shows an average adjusted spread of $2.50 per bale less than Market B. This difference should not all be attributed to the influence of gin buying, but this latter comparison is more indicative of that influence than is the comparison between the two ginner commission markets and the three non-ginner commission markets. This is due to the fact that in Market B the ginner buyer bought only a small proportion of cotton and he was, in reality, strictly a commission buyer. He bought cotton for a central market firm in competition with other commission buyers of the same firm and other firms. His opportunity for paying relatively high prices for cotton in order to attract business to his gin was very limited. In Market A, however, one of the ginner buyers was buying cotton for the gin company and it was possible for him to pay relatively high prices solely for the purpose of attracting farmers to the gin.

The adjusted spread for the non-competitive merchant markets averaged $4.05 per bale as compared to $ .55 in the competitive merchant markets, or a difference of $3.50. It is reasonable to attribute a large part of this difference in spread to the influence of the type of market. The average adjusted spread during the season for the merchant and ginner markets was $1.50 per bale or $ .95 more than for the competitive merchant markets.

The average spreads between local and central market prices for individual qualities of cotton varied considerably from those for all qualities of cotton combined. The average adjusted spread for 13/16 inch cotton in all local markets was a negative $2.00; that is, the adjusted local market price for 13/16 inch was $2.00 per bale above the central market price. The local market price for Middling 7/8 inch cotton averaged $ .20 per bale below central market prices as compared to $1.40 for 15/16 inch, $2.95 for 1 inch, $5.70 for 1 1/16 inches, $6.25 for 1 1/8 inches and $8.90 for 1 3/16 inches. As noted above, the average spread for all qualities was $2.20 per bale.

In the five commission markets, the average spread for all staple lengths adjusted to a middling grade basis was $1.40 per bale. The commission market prices for 13/16 inch cotton averaged $2.45 per bale above central market prices and those for 7/8 inch cotton averaged $ .45 per bale above central market prices. Commission market prices for 15/16 inch cotton averaged $ .25 per bale below central market prices as compared to $1.60 below for 1 inch, $4.00 below for 1 1/16 inches, $4.25 below for 1 1/8 inches and $7.25 below for 1 3/16 inches.

Merchant market prices for each staple length averaged considerably lower than those for commission markets. The average adjusted price for 13/16 inch cotton in merchant markets was $1.30 per bale above central market prices as compared to $1.00 below for 7/8 inch, $2.95 below for 15/16 inch, $5.15 below for 1 inch, $9.35 below for 1 1/16 inches, $12.75 below for 1 1/8 inches, and $16.80 below for 1 3/16 inches. The weighted average spread for all staple lengths in merchant markets adjusted to a middling grade basis was $3.25 per bale. Similar details for each market are shown in Table 8.

These data clearly indicate the tendency of local market prices for the shorter staple lengths to be relatively high and those for the longer staple lengths to be relatively low. A tendency for those markets in which the greater proportion of the cotton was of the longer staple lengths to show a greater average spread per bale for all qualities of cotton, may be noted also. This relationship indicates that, although communities which produced longer staple cotton received somewhat higher prices than communities which produced greater quantities of short staple cotton, the staple quality for each market was not fully reflected in the prices paid. Buyers in those markets in which all of the cotton was of the shorter staples evidently operated on a narrower margin than those

TABLE 8

Average adjusted spread between prices received by farmers in local markets of Louisiana and central market prices by staple lengths and the average staple length of cotton on which price data were obtained, 1928-29

Market	Average spread * per 500 pound bale								Average staple length of price study bales
	Staple length (inches)								
	13-16 and less	7-8	15-16	1 and 1 1-32	1 1-16 and 1 1-32	1 1-8 and 1 5-32	1 3-16 and 1 7-32	All Lengths	
	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Inches
Commission									
A	—3.30	—1.10	.10	2.05	5.95	8.25	....	.45	.943
B	—1.60	.75	1.50	3.60	7.40	9.10	....	3.05	.962
C	—4.40	—2.60	—2.15	.25	5.55	2.60	....	—2.40	.899
D	—2.65	1.70	.55	1.15	4.10	5.30	9.45	3.80	1.059
E	—4.25	—1.95	—1.15	—.15	3.75	5.50	4.40	.20	.981
Average	—2.45	—.45	.25	1.60	4.00	4.25	7.25	1.40	.979
Merchant									
F	—1.20	1.05	4.30	5.80	9.55	12.80	18.00	5.05	.965
G	—.95	1.45	3.35	5.50	9.80	13.20	16.35	4.70	.963
H	—1.80	—.50	.60	4.50	....	....	....	—.30	.891
J	—1.15	1.20	2.65	4.35	7.80	....	....	.35	.855
K	—1.95	.35	2.05	2.80	....	....	....	.85	.890
Average	—1.30	1.00	2.95	5.15	9.35	12.75	16.80	3.25	.937
All local	—2.00	.20	1.40	2.95	5.70	6.25	8.90	2.20	.962

*Adjusted for freight and compressing charges to New Orleans. Minus (—) indicates a higher adjusted price in local market than in central markets.

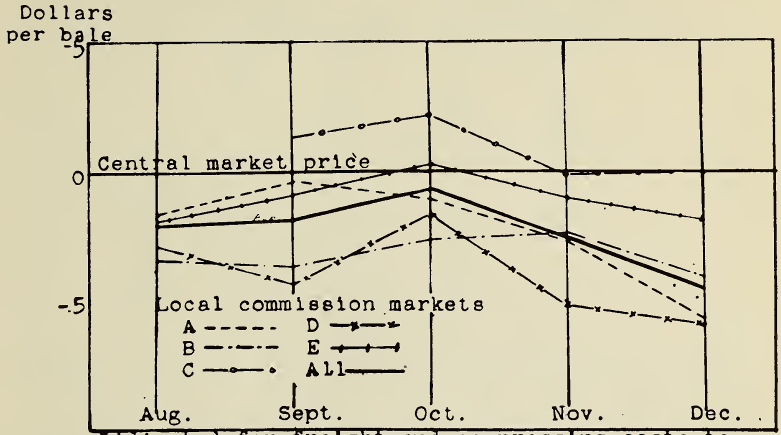
in which considerable quantities of longer staple cotton were marketed. This tendency may arise, in part, at least, from a greater cost in merchandising longer staple cotton. Greater cost in merchandizing may arise from unhedgeable risks of fluctuation in staple premiums, more interest on the investment, and difficulty of concentrating large even-running lots of staple cotton. On the other hand, a tendency doubtless exists for buyers in many local markets to more or less average their prices and to offset losses or small profits on short staple cotton with greater profits on longer staple cotton.

The spreads between central and local market prices for the various grades of cotton, like those for the various staple lengths, differed considerable. These spreads for all local markets adjusted to a ⅞ inch staple basis were as follows: Strict Good Middling, $1.95 per bale below central market prices; Good Middling, $1.60 below; Strict Middling, $ .90 below; Middling, $ .20 below; Strict Low Middling, $2.20 above; Low Middling, $4.85 above; and Strict Good Ordinary, $8.20 above central market prices. These data indicate again the tendency for relatively high prices to be paid for low quality cotton, and relatively low prices to be paid for high quality cotton.

The adjusted spread between corresponding local and central market prices changed considerably from month to month and this seasonal change was notably different for commission and merchant markets. In the commission markets, the price level was $ .45 below the average for the season in August, increased to only $ .30 below the average in September, increased further to $1.05 above this average in October, and then declined to $ .85 and $3.00 below the average in November and December respectively. It may be noted that the spread for commission markets was relatively small during the middle of the season, and was greater at the beginning and end, being especially low at the end. This is what might logically be expected, since during the height of the season when buyers are receiving a large volume of business they can operate on a narrower basis than toward the beginning or end of the season when only a few bales are being handled.

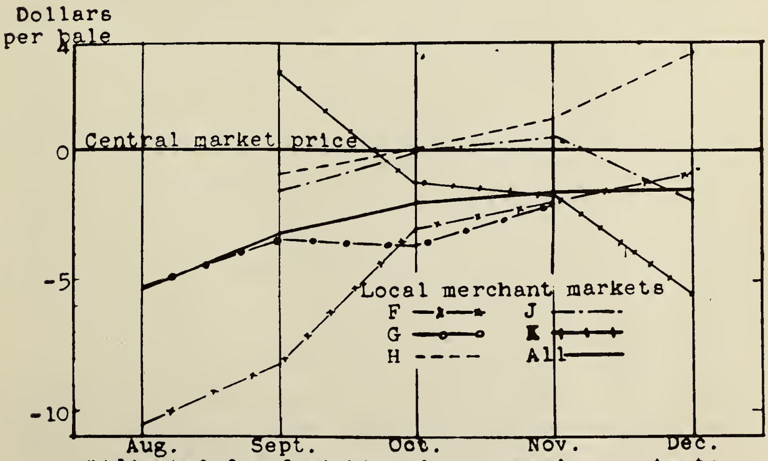
The adjusted spread in the merchant markets was very great during the first month of the season, but became less each month as the season advanced. The extent to which the average spread during each month of the season varied from the average for the entire season in the five merchant markets was as follows: August $2.35 per bale below; September $ .30 per bale below; October, $ .95 per bale above; November, $1.30 per bale above; and December $1.45 per bale above.

Fig. 7--Average adjusted Spread between Louisiana local commission market prices and central market prices by months, 1928



*Adjusted for freight and compressing costs to New Orleans.

Fig. 8--Average adjusted spread between Louisiana local merchant market prices and central market prices by months, 1928



*Adjusted for freight and compressing costs to New Orleans.

TABLE 9

Average adjusted spread between prices received by farmers in local markets of Louisiana and central market prices by months, 1928-29

Market	Average Spread * per 500 Pound Bale					
	August	September	October	November	December and later	Season
Commission	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
A	1.60	.30	1.00	2.65	5.65	.75
B	3.35	3.60	2.60	2.20	4.00	3.15
C	....	—1.35	—2.20	.15	0	—1.55
D	2.90	4.35	1.65	5.15	5.90	3.80
E	1.90	.70	—.30	1.00	1.85	.45
Average	2.10	1.90	.60	2.55	4.55	1.65
Merchant						
F	10.55	8.20	3.05	1.95	.80	5.00
G	5.25	3.45	3.65	2.10	....	3.80
H	....	.95	—.10	—1.15	—3.75	.40
J	....	1.55	.05	—.55	1.90	.70
K	....	—2.95	1.20	1.70	5.40	1.50
Average	5.30	3.25	2.00	1.65	1.50	2.95

*Adjusted for freight and compressing charges to New Orleans. Minus (—) indicates a higher adjusted price in local market than in central markets.

The seasonal change in the adjusted spreads for each of the five commission markets and for four of the five merchant markets agrees in general with the average for each of the respective groups. There is one notable exception, however, and that is Market K, the merchant and ginner market. It will be recalled that in the description of local market K it was stated that in this market the ginner buyer was active during only a part of the season. This ginner buyer purchased cotton in that market only during the first three or four weeks of the season, and it is very significant to note that the spread for that market was very small during the first month of the season, but after the first month there was a marked increase in the spread for that market. This indicates that competition between the ginner buyer and merchant buyer during the first month caused relatively high prices to be paid for cotton, but after the withdrawal of the ginner buyer, the merchant buyer, having very little competition, paid relatively low prices for cotton.

Some of the seasonal change in the adjusted spread in merchant markets may be explained by the direct relationship between spread and average staple length noted above. The average staple length of cotton on which data were obtained in each of these markets was longest early in the season and became shorter as the season advanced just as the average spread was greatest early in the season, and became narrower as the season advanced.

It is clearly evident that type of buyer is one of the most important factors affecting the spread between local and central market prices. The merchant markets showed a greater spread than commission markets, in spite of the fact that relatively more of the longer staples was marketed in the commission markets, and other things being equal, there was a tendency for short staple markets to show less spread. On an average, farmers in the merchant markets received considerably lower prices for the longer staples and slightly lower prices for shorter staples than those in commission markets..

In addition to the influence of type-of-buyer on the spread between local and central market prices and the association of greater spread with longer staple length there are a number of other factors which are important with respect to the adjusted spread. The narrow spread .for Markets C and E may have been due, largely, to the very active competition which existed between the commission buyers, and the method of handling cotton in these markets. In these markets, cotton warehouses were available and practically all cotton was purchased from farmers after it was placed in the local warehouse. It was purchased on warehouse weights and on samples secured at the warehouse.

Change in weight of cotton is a factor of considerable importance in some of the markets of Louisiana. In most of the markets studied the cotton was bought on gin weights, but in some instances the buyer weighed each bale on his own scales and paid for the cotton according to this weight, and as indicated above, in two of the markets studied compress or public warehouse weights were used. The change in weight varied considerably in different markets, in some markets no loss or even a slight gain was reported; however, in most of the markets the buyers reported a loss in weight. The highest estimated average loss in weight was 10 pounds per bale.

Data relative to loss in weight were obtained from the buyers' book in one local market. These data show that on 632 bales, the average loss in weight was 5.8 pounds per bale between the gin weight on which purchased, and the final outturn weight, on which sold. The loss in weight averaged about 10 pounds per bale during the first few weeks of the season and decreased as the season advanced to about 3 pounds per bale at the end of the season. Likewise, data were obtained in this same market relative to the loss in weight between the local gin weight, on which cotton was sold by the farmers, and the local compress weights. This loss in weight averaged 3.2 pounds for 581 bales. The average loss in weight between the local gin weight and the local compress weight was about 5 pounds early in the season and practically none at the end of the season. The heavy loss in weight during the early portion of the season, was of course, the result of "green" cotton, and considerable rainfall. Rainfall, however, was unusually light in this market during all but the first three or four weeks of the 1928-29 ginning season. The precipitation between September 5 and October 16 was less than two inches. About 80 per cent of the bales of the above sample was marketed during this period of unusually dry weather. In seasons of heavy rainfall a somewhat greater loss in weight might be expected.

VARIATION BETWEEN PRICE AND QUALITY FOR INDIVIDUAL BALES IN THE SAME MARKETS DURING ONE DAY

Presentation of the above analysis has been accomplished by the use of weighted averages or arithmetic means. The significance of such a mean is dependent upon the number and deviation of the individual observations in the series from which it is computed. The significance of the averages for all local markets combined was diminished in many cases by the fact that the averages for the commission markets and the merchant markets differed so greatly. Also, the significance of the averages for all commission or all merchant markets was often reduced by the great variability of the averages for the local markets. For, example, it was found that the average premium for $\frac{15}{16}$ inch cotton in all local markets combined was 15 cents per bale. This weighted average was computed from an average premium of $ .65 per bale in commission markets and a discount of $ .60 per bale in merchant markets. The average premium for the commission markets was in turn derived from averages for the local markets ranging from $ .15 per bale to $2.50 per bale and the average discount for the merchant markets was derived from averages ranging from a discount of $1.90 per bale to a premium of $ .25 per bale. Furthermore, it can be shown that the averages for some of the local markets are computed from widely different items. It is not feasible to present here all of the individual items in any series from which averages were computed for a local market during an entire season. Some idea as to the variability of the individual items, and one cause for this variability, however, can be obtained from a rather complete examination of the individual transactions in several of the local markets on a single day. The data for Market A are more nearly complete than those for any other local market, and, therefore, these data are presented first, and in greater detail than those for the other markets.

Prices received by farmers in Market A on September 15* for cotton classified according to the grade and staple designation of government classers and reclassified according to the grade and staple designation of the local buyers are shown in Tables 10 and 11.

Considering first the prices for cotton classified according to the grade and staple length designation of the government classers it may be noted that there was considerable irregularity in the prices paid. One bale called Strict Middling ⅞ inch brought 16.38 cents per pound while another brought 17.00 cents per pound. Of the Strict Middling $\frac{15}{16}$ inch cotton 2 bales brought 16.40 cents per pounds and 2 others brought 16.95 and 17.00 cents per pound. A bale of Strict Middling ⅞ inch sold for 17.00 cents while two bales of Strict Middling $\frac{15}{16}$ inch sold for 16.40 cents per pound. The range in prices for Middling ⅞ inch was from 16.25 cents to 16.65 cents per pound and that for Middling $\frac{15}{16}$ inch was from 16.40 cents to 17.25 cents per pound. A bale of Middling 1 inch sold for less than one of the bales of Middling $\frac{15}{16}$ inch.

Three bales of cotton with a staple length of $1\frac{1}{16}$ inches sold for the same price, 17.25 cents per pound, in spite of the fact that one of the bales was called Middling, another Strict Middling, and the other Good Middling. Perhaps the most marked irregularity may be noted in the Strict Low Middling cotton wherein a bale

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*September 15, 1928 was selected because it represents an active part of the season and because of the limited fluctuations in the price of cotton in the New York contract market. The difference between the high and low for the active month on that day was only 11 points or .11 cents per pound and therefore very little of the differences in prices received by farmers in local markets on that day could have been due to differences in price level regardless of the time of day at which the cotton was sold.

TABLE 10

Prices per pound received by farmers for cotton sold in Market A on September 15, 1928, classified according to grade and staple length designation of government classers

Grade	Staple Length (inches)					
	13-16	7-8	15-16	1	1 1-16	1 1-8
	Cents	Cents	Cents	Cents	Cents	Cents
Good Middling........	....	....	....	....	17.25	....
Strict Middling......	....	16.38	16.40	....	17.25	....
	....	17.00	16.40	....	....	....
	....	....	16.95	....	....	....
	....	....	17.00	....	....	....
Average................	....	16.69	16.69	....	17.25	....
Middling..................	....	16.25	16.40	16.95	17.25	....
	....	16.40	16.75	....	....	....
	....	16.65	17.25	....	....	....
Average................	....	16.43	16.47	16.95	17.25	....
Strict Low Middling.............	16.60	....	....	16.10	....	17.30

called $\frac{13}{16}$ inch by the government classers sold for 16.60 cents per pound and a bale called 1 inch brought only 16.10 cents per pound. The average premium quoted in the central markets on that day for 1 inch cotton over $\frac{13}{16}$ inch cotton was 1.26 cents per pound but apparently instead of the farmer with the inch cotton receiving a premium of 1.26 cents per pound he received a discount of .50 cents per pound.

The average premium for $\frac{15}{16}$ inch over 7/8 inch based on the classing of government classers was only .02 cents per pound as compared to .24 cents or 12 times as much in central markets that day. The local market premium for 1 inch was .50 as compared to .76 cents per pound in central markets. The premiums for $1\frac{1}{16}$ inches were .69 and 1.75 cents per pound in the local and central markets, respectively. Average grade differences in Market Market A on September 15 were similar to those in central markets, except for the bale called Good Middling for which no premium was paid in the local market.

A very different picture was obtained, however, when these same prices were reclassified according to the grade and staple designations of the cotton buyers in Market A. (Table 11). Of the 5 bales called Strict Middling $\frac{15}{16}$ inch by the local buyers, the farmers received 16.40 cents per pound for 4 and 16.38 cents per pound for the other. One bale called Middling $\frac{15}{16}$ inch by the local buyer was sold for 16.10 cents per pound as compared to an average price of about 16.40 cents per pound for Strict Middling $\frac{15}{16}$ inch. Of three bales called Strict Middling 1 inch by the local buyers, the farmers received 16.95 cents per pound for 2 bales and 17.00 cents per pound for the other bale. Four bales were called Strict Middling $1\frac{1}{32}$ inches by the local buyers and 17.25 cents per pound were received by the farmers for each bale. A similar consistency may be noted throughout this table.

TABLE 11

Prices per pound received by farmers for cotton sold in Market A on September 15, 1928 classified according to grade and staple length designations of local buyers

Grade Designation	Staple Length Designation				
	15-16	31-32	1	1 1-32	1 1-16
Strict Middling	16.38	....	16.95	17.25	....
	16.40	....	16.95	17.25	....
	16.40	....	17.00	17.25	....
	16.40	....	....	17.25	....
	16.40	....	....	....	....
Average	16.40	....	16.97	17.25	....
Middling	16.10	16.25	16.60	17.00	17.30
	....	....	16.65	....	....
	....	....	16.75	....	....
Average	16.10	16.25	16.65	17.00	17.30

The average premium for 1 inch over $\frac{15}{16}$ inch cotton in Market A based on the classing of local buyers was .56 cents per pound as compared to .52 cents in central markets. The corresponding premiums for $1\frac{1}{16}$ inches was 1.20 cents and 1.51 cents per pound, respectively. The average premium for Strict Middling over Middling was .29 cents per pound in Market A as compared with .25 cents in central markets.

From the data just presented it is clearly evident that on September 15, 1928, the local buyers in Market A did pay premiums and discounts for the various grade and staple qualities of cotton in accordance with their determination of these qualities and that these premiums and discounts were well in line with those prevailing in the central markets. There was a marked difference, however, in the determination of grade and staple length by these local buyers and by the government classers. A bale of cotton called Strict Low Middling $\frac{13}{16}$ inch by the government classers brought 16.60 cents per pound, while a bale called Strict Low Middling 1 inch cotton brought only 16.60 cents per pound. According to the local buyer, however, the bale for which he paid 16.10 cents per pound was Middling $\frac{15}{16}$ inch cotton and the bale for which he paid 16.60 cents per pound was Middling 1 inch cotton. This difference of .50 cents per pound was well in line with the premium for 1 inch cotton over $\frac{15}{16}$ inch cotton prevailing in the central markets.

Of two bales called Strict Middling 7/8 inch by the government classers, one sold for 16.38 cents per pound, the other for 17.00 cents per pound. But the local buyer called the bale for which he paid 16.38 cents per pound, Strict Middling $\frac{15}{16}$ inch and the other for which he paid 17.00 cents per pound, Strict Middling 1 inch. This difference of .62 cents per pound was slightly greater than the central market difference for these staple lengths. Furthermore, the difference in the average price received by farmers for cotton called 7/8 inch by the government classers and the average price for cotton called $\frac{15}{16}$ inch was only 2 points or .10 cents per 500 pound bale against the central market difference of 25 points or $1.25 per bale. On the other hand, all of the bales called 7/8 inch by the government classers were either $\frac{15}{16}$, $\frac{31}{32}$, or 1 inch cotton, according to the local buyers.

It is obvious that marked variations in grade and staple designations might easily occur when only one day's marketing is analyzed, which would not be apparent at all if a large volume of local sales were presented as averages. These specific instances are noted, however, in order to give a better understanding of the mass of data presented in this analysis, and it is believed that these discrepancies are typical of conditions existing in many of the Louisiana local markets.

The spread between prices received by farmers in this local market for the various qualities of cotton as determined by the local buyers and the Galveston* spot prices for the same qualities ranged from 105 points or $5.25 per 500 pound bale to 115 points or $5.45 per bale. The average difference was 108 points or $5.40 per bale. The local buyer who purchased 18 of the 19 bales of cotton for which these data were obtained, told the writer that his policy was to base the prices he paid to farmers on the Galveston spot market quotations allowing 138 points per pound or $6.90 per 500 pound bale for expenses and carrying charges. These expenses were itemized as follows:

Freight and compressing 69½ cents per 100 pounds or	$3.48 per bale
Loss in weight 40 points or	2.00 per bale
Buyer's commission 20 points or	1.00 per bale
Drayage—gin to depot 5 points or	.25 per bale
Insurance and re-discount 3½ points or	.17 per bale
Total 138 points or	$6.90 per bale

On September 15, 1928, however, instead of allowing 138 points per pound or $6.90 per bale for carrying charges, the above analysis indicates that the averaged spread was 108 points or $5.40 per bale. One or more of several factors may have contributed to this difference. First, the local buyer may have been using quotations furnished by a private firm in Galveston and these quotations may have differed from the official quotations. Second, the local buyer may have been using the quotations for the previous day when prices averaged 10 points higher. Third, this buyer was buying for the cooperating gin company on commission and the gin company may have taken a loss on this cotton in order to gain business. The last reason seems plausible, because this buyer outbid all other buyers on most of the cotton in the market on September 15, 1928, and the manager of the gin company said that several hundred dollars were lost by the gin company on the cotton purchased. This loss, however, was offset by the fact that the gin gained additional business by paying high prices for cotton. This company had a very successful season in 1928, in spite of the fact that the cotton crop in that community was short and nearby gins experienced a relatively small volume of business.

According to the grade and staple length designation of government classers, the prices received by farmers in Market A for

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*Galveston quotations were used because it is the market to which most of this cotton was sent and Galveston quotations were used by the local buyers.

the various qualities of cotton range from .90 cents per pound above the Galveston price for cotton called Strict Low Middling $\frac{13}{16}$ inch to 1.84 cents per pound below the Galveston price for cotton called Good Middling $1\frac{1}{16}$ inches. The average difference between the local market and Galveston prices was 79 points per pound or $3.95 per bale. This difference or spread based on the grade and staple designations of the government classers corresponds to the above noted spread of $5.40 based on the grade and staple designations of the local buyers, the observed difference in spread being due to a tendency on the part of the government classers to call more of the cotton as of the shorter staple lengths.

Assuming that these 19 bales when shipped to Galveston were purchased exactly in accordance with the grade and staple designations of the government classers and at the same level of prices at which they were purchased from the farmer, the gin company for which the cotton was purchased would have had $3.95 per bale with which to pay freight, and compressing, drayage, insurance, and re-discount, local buyer's commission, and loss in weight. Freight and compressing, drayage, and insurance and re-discount amounted to $3.90 per bale and consequently the gin company would have lost $ .95 per bale commission to the local buyer, probably about $1.00 to $2.00 per bale for loss in weight, and the cost of selling the cotton. It is hardly probable that the gin company incurred such heavy losses as these, but the company claimed to have incurred considerable losses.

It was impossible to obtain complete data with respect to both grade and staple designation in the other markets studied and therefore such an analysis as was made for Market A can not be made for the other markets. An analysis, however, of the transactions on September 15, 1928, at some of the other markets, using only the grade and staple length designation of the government classers seems essential to this study.

Prices received by farmers in Market D on this date show considerable variation and inconsistency when classified according to the grade and staple length designation of government classers. A bale of cotton called Strict Middling 1⅛ inches sold for 16.50 cents per pound while another bale of the same grade but a designated staple length of only ⅞ inch sold for 17.00 cents per pound. One bale called Good Middling $1\frac{1}{16}$ inches sold for only 15.50

cents per pound and another of the same designated grade and staple length sold for 18.00 cents per pound. Similar irregularities may be noted throughout Table 12.

TABLE 12

Prices per pound received by farmers in Market D, classified according to the grade and staple length designation of government classers, corresponding prices in central markets and the spread between these prices on September 15, 1928

Staple length	GRADE (WHITE)								
	Good Middling			Strict Middling			Middling		
	Local Market	Central Markets	Spread	Local Market	Central Markets	Spread	Local Market	Central Markets	Spread
Inches	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents	Cents
7-8	....	....	....	17.00	16.98	—.02	....	....	....
15-16	17.00	17.36	.36	16.50	17.22	.72	16.50	16.97	.47
	17.00	17.36	.36	17.00	17.22	.22	....	....	....
Average	17.00	17.36	.36	....	....	....	16.50	16.97	.47
1	17.00	17.88	.88	....	....	....	16.50	17.49	.99
	17.50	17.88	.38	....	....	....	17.00	17.49	.49
Average	17.25	17.88	.63	....	....	....	16.75	17.49	.74
1 1-16	15.50	18.87	3.37	16.75	18.73	1.98	....	....	....
	16.62	18.87	2.25	....	....	....	....	....	....
	18.00	18.87	.87	....	....	....	....	....	....
Average	16.71	18.87	2.16	16.75	18.73	1.98	....	....	....
1 1-8	17.00	19.52	2.52	16.50	19.38	2.88	....	....	....
	18.00	19.52	1.52	....	....	....	....	....	....
	18.75	19.52	.77	....	....	....	....	....	....
Average	17.92	19.52	1.60	16.50	19.38	2.88	....	....	....
1 3-16	....	....	....	18.00	20.23	2.23	....	....	....

In general it may be said that there was a slight tendency on the part of the buyers in Market D to make differences in the prices paid to farmers in accordance with the differences in staple quality as determined by government classes, but these differences in prices were relatively insignificant and show numerous inconsistencies. Differences in grade quality, however, were rather consistently reflected in the differences in prices paid to farmers.

The range in prices received by farmers for the 19 bales of cotton sold in Market D on September 15, 1928, was from 15.50 cents per pound to 18.75 cents per pound, or a difference of 3.25 cents. Of the 19 prices shown, 7 are below 17.00 cents per pound, 8 are as high as 17.00 cents per pound but below 18.00 cents, and 4 are 18.00 cents per pound or higher. Such a range in prices is believed to be significant and it seems reasonable to assume that these variations in price were based largely on the local buyers' interpretation of quality. If such were the case, however, their interpretation of quality and especially staple quality differed considerably from the interpretation of the government cotton classers.

The difference or spread between the local market prices and the corresponding central market prices varied from — .02 cents per pound to + 3.37 cents per pound, the minus sign indicating a higher price in the local market and the plus sign a higher price in the central markets. The average spread was + 1.22 cents per pound or $6.10 per bale. As was noted with respect to Market A, there was a definite tendency for spread to be greater for the longer staple lengths than for the shorter staple lengths.

A like analysis of the data for each of the other commission markets reveals similar variations and irregularities in the prices paid to farmers when these prices are classified according to the grade and staple classifications of the government classers.

In Market F, one of the non-competitive ginner, storekeeper markets, data were obtained on 15 bales of cotton sold individually on September 15, 1928. In spite of the fact that according to the government classers the staple length of these bales ranged from $\frac{13}{16}$ of an inch to 1⅛ inches and all of them were either Middling or Strict Middling in grade, the farmers received 15 cents per pound for nearly every bale. Two bales called Middling $\frac{13}{16}$ of an inch brought the farmers 15.00 cents per pound and two bales called Strict Middling 1⅛ inches also brought 15.00 cents per pound, although in the central markets, the latter quality was commanding a premium of $15.45 per bale over the former. (Table 14).

The transactions in this market on September 15, 1928, furnish a typical example of "hog-round" cotton buying in local markets with no evident attempt on the part of the local buyer to differentiate between the various qualities of the cotton purchased and to make differences in the prices paid to the farmers.

TABLE 13

Prices per pound received by farmers in Local Market F, classified according to the grade and staple length designations of government classers, corresponding prices in central markets, and the spread between these prices on September 15, 1928

Staple length	GRADE (WHITE)					
	Strict Middling			Middling		
	Local Market Price	Central Market Price	Spread	Local Market Price	Central Market Price	Spread
Inches	Cents	Cents	Cents	Cents	Cents	Cents
13-16	....	....	....	15.00	16.23	1.23
	....	....	....	15.00	16.23	1.23
Average	....	....	....	15.00	16.23	1.23
7-8	15.50	16.98	1.48	15.00	16.73	1.73
	15.00	16.98	1.98	15.00	16.73	1.73
	15.00	16.98	1.98	....	....	....
Average	15.17	16.98	1.81	15.00	16.73	1.73
15-16	15.00	17.22	2.22	15.00	16.97	1.97
	15.00	17.22	2.22	....	....	....
Average	15.00	17.22	2.22	15.00	16.97	1.97
1	....	....	....	15.00	17.49	2.49
1 1-16	....	....	....	15.25	18.48	3.23
1 1-8	15.00	19.38	4.38	....	....	....
	15.00	19.38	4.38	15.00	19.13	4.13
Average	15.00	19.38	4.38	15.00	19.13	4.13

Average spread: 2.43 cents per pound or $12.15 per bale.

The cotton buyer in local Market F not only failed to make differences in the prices paid to farmers on the basis of quality but also paid prices which were considerably below the price prevailing in the central markets on September 15, 1928. For the poorest quality of cotton shown, the local market prices were 1.23 cents per pound or $6.15 per bale below the corresponding average price in central markets as compared to 4.38 cents per pound or $21.90 per bale for the highest quality. The average difference between the local and central market prices was 2.43 cents per pound or $12.15 per bale for this market, as compared to $3.95 for Market A, $4.20 for Market B, and $6.10 for Market D. Furthermore, the freight charges on cotton from Local Market F to the nearest central market were less than those of any of the other markets studied, and Market F is the only one of the four markets mentioned above where there was not an average loss in weight on cotton purchased.

Corresponding data for each of the other merchant markets are similar to that presented for Market F. In each market practically the same price was paid for every bale of cotton regardless of its quality. There was less spread, however, between local and central market price for the competitive merchant markets than for the others.

COMPARISON OF COTTON CLASSING BY GOVERNMENT CLASSERS AND LOCAL BUYERS

In the analysis of the transaction in Market A, a marked difference in the grade and staple length designations of government classers and local buyers was noted and inconsistencies in the prices received by farmers were explained, largely, by this difference in cotton classing. A more complete analysis of such data is essential to this study. The price data alone show *what* conditions existed with respect to the problem of price-quality relationship based on the grade and staple length designations of government classers. An analysis of the grade and staple length designations of government classers and local buyers, however, helps to answer to the question of *why* such conditions prevailed.

Difficulty was experienced in most of the local markets studied, in obtaining grade and staple length designations of the local buyers. This was due to the fact that the local buyers in most markets, often made no record of their grade and staple designations, although in a few markets no attempt was made to determine the grade and staple length of the cotton purchased. Staple lengths designations, especially, were not obtainable.

Data were obtained in Market A, however, relative to the staple designation by the local buyers on 1,134 bales on which staple length designations by government classers were available also. Of the 1,134 bales the government classers designated 5.5 per cent as $\frac{13}{16}$ inch and 23.4 per cent as $\frac{7}{8}$ inch, whereas the local buyers designated none as of either of these staple lengths. The government classers designated 36.5 per cent as $\frac{15}{16}$ inch as compared to

44.9 per cent by the local buyers. As 1 inch the government classers designated 28.3 per cent and the local buyers 46.9 per cent. As $1\frac{1}{16}$ inches the government classers designated 5.1 per cent and the local buyers 7.6 per cent. The per cents designated at 1⅛ inches were 1.2 and 0.6 by the government classers and the local buyers, respectively. (Table 14)

TABLE 14

Classification by Government classers and by local buyers of 1,134 bales of cotton sold in Market A, by staple lengths, 1928-29

Staple Length	Quantity according to		Proportion according to	
	Government Classers	Local Buyers	Government Classers	Local Buyers
	Bales	Bales	Per Cent	Per Cent
13-16 and less	62	0	5.5	0
7-8 and 29-32	265	0	23.4	0
15-16 and 31-32	414	509	36.5	44.9
1 and 1 1-32	321	532	28.3	46.9
1 1-16 and 1 3-32	58	86	5.1	7.6
1 1-8 and 1 5-32	14	7	1.2	0.6
Total	1134	1134	100.0	100.0

Of 62 bales designated by the government classers as $\frac{13}{16}$ inch the local buyers designated 67 per cent as $\frac{15}{16}$ inch, 31 per cent as 1 inch, and 2 per cent as $1\frac{1}{16}$ inches. (Table 15). Of the 265 bales of cotton designated by the government classers as ⅞ inch, the local buyers designated 58 per cent as $\frac{15}{16}$ inch, 38 per cent as 1 inch, and 4 per cent as $1\frac{1}{16}$ inches. Similarly the cotton designated by the government classers as of each of the other staple lengths was distributed among the various staple lengths by the local buyers. It may be noted that, although some degree of correlation exists between staple designations by the government classers and the local buyers, there was also a very marked difference in the classing of the two. The cotton which the government classers called $\frac{13}{16}$, ⅞, and $\frac{15}{16}$ inch cotton was all called $\frac{15}{16}$ inch and longer by the local buyers. The cotton which was $1\frac{1}{16}$ and 1⅛ inches according to the government classers, the local buyers tended to call shorter than those staple lengths. The average staple length of the 1,134 bales was slightly more than $\frac{15}{16}$ of an inch according to the government classers and slightly over $\frac{31}{32}$ of an inch according to the local buyers.

TABLE 15

Quantitative and percentage distribution by staple lengths according to government classers, of cotton called each specified staple length by local buyers, and by staple lengths accord'ng to local buyers, of cotton called each specified staple length by government classers, Market A, Crop of 1928

Government classers	Quantitative distribution according to: Local buyers					Percentage distribution according to: Government classers of cotton called each staple length by Local buyers					Local buyers of cotton called each staple length by government classers				
	15–16	1	1 1–16	1 1–8	Total	15–16	1	1 1–16	1 1–8	Total	15–16	1	1 1-16	1 1–8	Total
	Bales	Bales	Bales	Bales	Bales	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
13-16	42	19	1	0	62	8.3	3.6	1.2	....	5.5	67.7	30.7	1.6	....	100.0
7-8	155	100	10	0	265	30.5	18.8	11.6	....	23.4	58.5	37.7	3.8	....	100.0
15-16	202	185	23	4	414	39.6	34.8	26.7	57.1	36.5	48.8	44.7	5.6	0.9	100.0
1	99	186	35	1	321	19.4	34.9	40.7	14.3	28.3	30.9	57.9	10.9	0.3	100.0
1 1-16	8	38	10	2	58	1.6	7.1	11.6	28.6	5.1	13.8	65.5	17.2	3.5	100.0
1 1-8	3	4	7	0	14	0.6	0.8	8.2	....	1.2	21.4	28.6	50.0	....	100.0
Total	509	532	86	7	1134	100	100	100	100	100	44.9	46.9	7.6	0.6	100.0

Of the 1,134 bales, the local buyers agreed with the government classers on only 398 bales or 35 per cent. In other words, for 65 per cent of the bales, the staple length designation of the local buyers were different from those of the government classers. The percentage of bales on which there was complete agreement ranged from 0 for $\frac{13}{16}$, $\frac{7}{8}$ and $1\frac{1}{8}$ inch to 58 per cent for 1 inch. Furthermore, using 1 inch cotton as an example, it may be noted that the 186 bales, on which there was complete agreement between the local buyers and the government classers, constituted only 35 per cent of the bales called 1 inch by the local buyers. In other words, of the 321 bales called 1 inch by the government classers 186 or 58 per cent were also called 1 inch by the local buyers, but these 186 bales accounted for only 25 per cent of all (532) the bales called 1 inch by the local buyers.

Of the 321 bales called 1 inch by the government classers 320 or practically 100 per cent were called either $\frac{15}{16}$, 1, or $1\frac{1}{16}$ inches by the local buyers. The buyers did not differ with the government classers by more than $\frac{1}{16}$ of an inch on 81 per cent of all the bales.

A very significant comparison is presented in Table 16. This table shows the extent to which the staple length designations of the government classers were reflected by those of the local buyers, just as the price data presented previously indicated the extent to which central market premiums and discounts, based on staple length as determined by government classers, were reflected by the prices paid by buyers in local markets.

It may be noted that the difference in average staple length between the cotton designated as $\frac{13}{16}$ of an inch and $\frac{7}{8}$ of an inch by the government classers was .0625 inch according to the government classers and only .0072 inch or 11.5 per cent as much according to the local buyers. Similarly only 13.3 per cent of the difference between $\frac{7}{8}$ and $\frac{15}{16}$ inch cotton according to government classers was reflected in the staple designations for the same cotton by the local buyers. The corresponding percentages of the differences between $\frac{7}{8}$ of an inch and 1 inch; $1\frac{1}{16}$ inches, and $1\frac{1}{8}$ inches were 17.7, 21.7, and 20.8 respectively. The weighted average of these percentages of the extent to which the differences in staple length according to government classers were reflected in the designations of local buyers is 15.5 per cent. This low percentage is very significant. Even if the local buyers in Market A paid full central market premiums and discounts for staple length as they interpreted staple length, the fact that their interpretation of differences in staple length reflected difference in staple length as interpreted by government classers to the extent of only about 15 per cent on an average, precludes the possibility that the price paid to farmers in Market A when classified according to the staple length designations of government classers would be greater than about 15 per cent of the central market premiums and discounts.

TABLE 16

Comparison of differences in staple length designations by government classers with average differences in staple length designations of local buyers in Market A, Crop of 1928

Staple designations of government classers		Average staple length of same bales according to:		Difference between base staple lengths and other staple lengths according to:		Percentage difference according to local buyers was of that according to government classers
Length	Bales	Govt. classers*	Local buyers†	Govt. classers	Local buyers	
Inches	Number	Inches	Inches	Inches	Inches	Per Cent
13-16......	62	.8125	.9586	—.0525	—.0072	11.5
7-8(base)	265	.8750	.9658	.0000	.0000	.0
15-16......	414	.9375	.9741	.0625	.0083	13.3
1..............	321	1.0000	.9879	.1250	.0221	17.7
1 1-16......	58	1.0625	1.0064	.1875	.0406	21.7
1 1-8........	14	1.1250	1.0178	.2500	.0520	20.8
All lengths....	1134	.9424	.9774	....	....	15.5

*Decimal equivalents of original designations, i. e. $\frac{13}{16}$ inch equal .8125 inch.

†Computed from data shown in Table 14. For example, of the 62 bales called $\frac{13}{16}$ inch by government classers, 42 were called $\frac{15}{16}$ inch, 19 were called 1 inch and 1 was called $1\frac{1}{16}$ inches by the local buyers. The weighted average of buyers' designation was about 61/64 inch which is expressed as a decimal fraction. .9586 inch.

Premiums and discounts for staple length actually received by farmers in Market A were only about 12.8 per cent of those in central markets. This average percentage of 12.8 is weighted the same and is comparable to the percentage (15.5) mentioned above. These two percentages indicate that only about 17.5 per cent of the difference between central market and local market premiums and discounts based on the government classing was due to a failure on the part of the local buyers to pay these premiums on the basis of their interpretation of differences in staple length. The other 82.5 per cent of the failure of premiums to be reflected, may be accounted for by the failure of the local buyers' designation of staple length to agree with those of the government classers.

Grade designations of buyers were obtained in four local markets for a total of 3,253 bales. (Table 17). There was a definite tendency for local buyers to call practically all of the cotton as of one or two of the middle grades, usually either Middling and Strict Middling or Middling and Strict Low Middling. This tendency was apparent in each of the four markets for which data were available, and was especially marked in Markets G and B. On the other hand, the government classers usually made a more or less normal distribution of the cotton throughout the range of grades. The local buyers called 65.3 per cent of the 3,253 bales, Middling, as compared with 38.3 per cent called Middling by government classers. In each of the four markets, A, B, G, and J, the cotton was graded somewhat higher by government classers than by local buyers.

The extent to which the government classers and local buyers agreed on the grade of individual bales varied from 33.0 per cent for Market B to 58.6 per cent for Market J. (Table 18). The corresponding per cents for Markets A and G were 45.8 and 40.0, respectively. Of the 3,253 bales on which data were obtained in the four markets, the local buyers and government classers agreed on the grade of 1,346 bales or 41.8 per cent. For the middle grades, the extent to which local buyers agreed with government classers was much greater than for the higher or the lower grades. This tendency doubtless arises in part from the fact that the local buyers called a relatively greater proportion of the bales one of the middle grades, and therefore, there was a probability for a relatively greater proportion of bales to be included in the middle grades by government classers. For example, for Market G it may be noted that of the 576 bales called Middling by government classers, the local buyer called 457 or 80 per cent Middling, also. These 457 bales, however, constituted only about 41 per cent of all the (1102) bales called Middling by the local buyer. In this connection it is interesting to note that 80 per cent of all the

TABLE 17

Grade of cotton sold in four local markets of Louisiana during 1928-29 according to Government classers and local buyers, in bales and percentages

Grade	Market A		Market B		Market G		Market J		Total	
	Gov't classers	Local buyers	Gov't classers	Local buyers	Gov't classers	Local buyers	Gov't classers	Local buyers	Gov't classers	Local buyers
	Bales	Bales	Bales	Bales	Bales	Bales	Bales	Bales	Bales	Bales
S. G. M.	0	0	5	0	0	0	0	0	5	0
G. M.	119	4	90	0	36	0	14	0	259	4
S. M.	480	436	288	178	371	6	69	83	1,208	703
Middling	516	655	129	337	576	1,102	26	28	1,247	2,122
S. L. M.	75	94	46	34	290	267	2	0	413	395
L. M.	7	6	3	12	104	6	0	0	114	24
S. G. O.	0	3	0	0	6	2	0	0	6	5
G. O.	1	0	0	0	0	0	0	0	1	0
All Grades	1,198	1,198	561	561	1,383	1,383	111	111	3,253	3,253
	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent	Per cent
S. G. M.	0	0	0.9	0	0	0	0	0	0.2	0
G. M.	9.9	0.3	16.0	0	2.6	0	12.6	0	8.0	0.1
S. M.	40.1	36.4	51.3	31.7	26.8	0.4	62.2	74.8	37.1	21.6
Middling	43.2	54.7	23.0	60.1	41.7	79.6	23.4	25.2	38.3	65.3
S. L. M.	6.2	7.9	8.2	6.1	21.0	19.4	1.8	0	12.7	12.1
L. M.	0.5	0.5	0.6	2.1	7.5	0.4	0	0	3.5	0.7
S. G. O.	0	0.2	0	0	0.4	0.2	0	0	0.2	0.2
G. O.	0.1	0	0	0	0	0	0	0	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

cotton for which data were obtained in Market G was called Middling by the local buyer, and the local buyer agreed with the government classers on 80 per cent of the bales which these classers called Middling. Theoretically, if the 80 per cent of all cotton called Middling by local buyers had been selected at random without even sampling the cotton, approximately 80 per cent of the cotton called Middling by the government classers would have been included in the cotton called Middling by the local buyer. When the above data were being obtained in Market G, it was observed that practically all of the cotton had been called Middling until toward the end of the season and thereafter most of it had been called Strict Low Middling. It seems evident therefore, that the local buyer in Market G failed, largely, to grade the cotton as it was graded by government classers.

TABLE 18.

Percentage of individual bales on which the grading of local buyers agreed with that of government classers in four markets of Louisiana, Crop of 1928

Grade	MARKET				Total
	A	B	G	J	
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
S. G. M.	....	0	....	....	0
G. M.	.8	0	0	0	.2
S. M.	42.7	31.0	.05	78.3	29.1
Mid.	63.4	67.0	79.5	42.3	70.7
S. L. M.	21.3	15.0	29.3	0	26.2
L. M.	0	0	3.8	......	3.5
S. G. O.	0	0	0	....	0
G. O.	0	0	....	....	....
All Grades	45.8	33.0	40.0	58.6	41.8

Comparisons similar to the above may be made for other markets. In Market A, the local buyers called 55 per cent of all the cotton Middling and agreed with the government classers on 63 per cent of the bales called Middling by them. The corresponding per cents for Market B were 60 and 67. The buyers in Market J called 75 per cent of all the cotton Strict Middling, and agreed with the government classers on 78 per cent of the cotton which they had called Strict Middling. From the above data, it seems logical to infer that agreement in the grade designation of a bale of cotton, especially in the merchant buyer markets, was largely a matter of chance and the percentage of agreement for a particular grade of cotton was determined to a great extent by the percentage of all cotton called that grade by the local buyers. The need for standardization and uniformity in cotton classing as a basis for making differences in prices in accordance with differences in quality is clearly apparent.

SUMMARY

About 30 per cent of the central market premiums and discounts for staple lengths other than $\frac{7}{8}$ inch were reflected in prices received by farmers in the 10 local markets of Louisiana studied. The extent to which premiums and discounts for staple length were received by farmers differed considerably in the various local markets and types of local markets. Staple length was recognized to a considerable degree in the commission-buyer markets as a whole and especially in those in which the influence of ginner buying was absent. For all of the commission markets combined central market prices differences were received by farmers to the extent of about 50 per cent.

Among the five merchant markets the data for only two, the competitive merchant markets, indicate positive reflection of central market premiums and discounts for staple length to any extent, whatsoever. The average percentage for these two markets was about 10. In the non-competitive merchant markets, there seems to have been a total disregard of staple premiums and discounts, with farmers receiving approximately the same price for $\frac{13}{16}$ inch cotton as for cotton with a staple length of $1\frac{3}{16}$ inches.

Perhaps the most marked irregularity with respect to staple premiums and discounts in all of the local markets was the universal failure to discount $\frac{13}{16}$ inch cotton to an appreciable extent.

Grade differences were received by farmers in the ten local markets studied to a slightly greater extent than were staple premiums and discounts. However, based on the grade designations of government cotton classers, only about one-third of the central market premiums and discount for grade were received by farmers in the markets studied. Generally speaking, the failure to pay premiums for grades higher than Middling was about the same as the failure to discount grades lower than Middling. The various markets differed considerably in the extent to which grade differences were received by farmers, but the type of market seems to have been less significant with regard to grade differences than to staple premiums and discounts. The average percentage reflection of central market grade differences in all commission markets combined was 44.7 per cent as compared to 19.0 per cent for the merchant markets.

The average spread or difference between central market prices and corresponding local market prices, adjusted for differences in freight, and compressing charges, was considerably greater for merchant markets than for commission markets. This spread was greatest for the non-competitive merchant markets and smallest for the non-ginner commission markets. The adjusted spread was $2.20 per bale for all local markets, $1.95 per bale for all commission markets, and $2.95 for all merchant markets. Average adjusted prices in individual markets varied from about $1.64 per bale above central market prices in Market E to about $5.00 per bale below central market prices in Market F.

The average adjusted spread between local and central market prices varied considerably. Adjusted local market prices for $\frac{13}{16}$ inch cotton averaged $2.00 per bale above central market prices. The average adjusted prices paid to farmers for each of the other staple lengths were below corresponding central market prices, the amount per bale being: $ .20 for $\frac{7}{8}$ inch; $1.40 for $\frac{15}{16}$ inch; $2.95 for 1 inch; $5.70 for $1\frac{1}{16}$ inches; $6.25 for $1\frac{1}{8}$ inches and $8.90 for $1\frac{3}{16}$ inches. Average adjusted prices for the shorter staple lengths were slightly lower in merchant markets than in commission markets and for the longer staple lengths were considerably lower in the former than in the latter.

A direct relationship was noted between the average spread between local and central market prices and the average staple length of cotton produced. This relationship indicates that, although communities which produced longer staple cotton received somewhat higher actual prices than other communities, the superior quality of the cotton was not fully reflected in average prices paid.

The seasonal change in the spread between local and central market prices was notably different in commission markets and merchant markets. For the commission markets this spread was relatively narrow during the middle of the season and was wider at the beginning and end of the season,—especially the latter. This change seems quite natural inasmuch as during the height of the season when buyers were receiving a large volume of business they could operate on a narrower basis than toward the beginning or end of the season when only a few bales were being marketed. For the merchant markets the spread was very wide at the beginning of the season and became narrower as the season advanced. This seasonal change was accounted for, largely, by the decrease in the average length of staple in these markets as the season advanced.

Marketing facilities available in local markets were found to have an appreciable influence on average local market prices. The least spread between central market prices and local market prices was for the two markets at which a warehouse was available and cotton was hauled direct from the gin to the warehouse, and then sold on warehouse weights and samples.

The average loss or gain in weight of cotton bales affects the prices paid for cotton. Some buyers reported no average loss in weight, while others reported an average loss of as much as 10 pounds per bale. Data secured at one market showed an average loss of nearly 6 pounds per bale between the gin weight on which the cotton was purchased and the weight on which it was sold by the buyers.

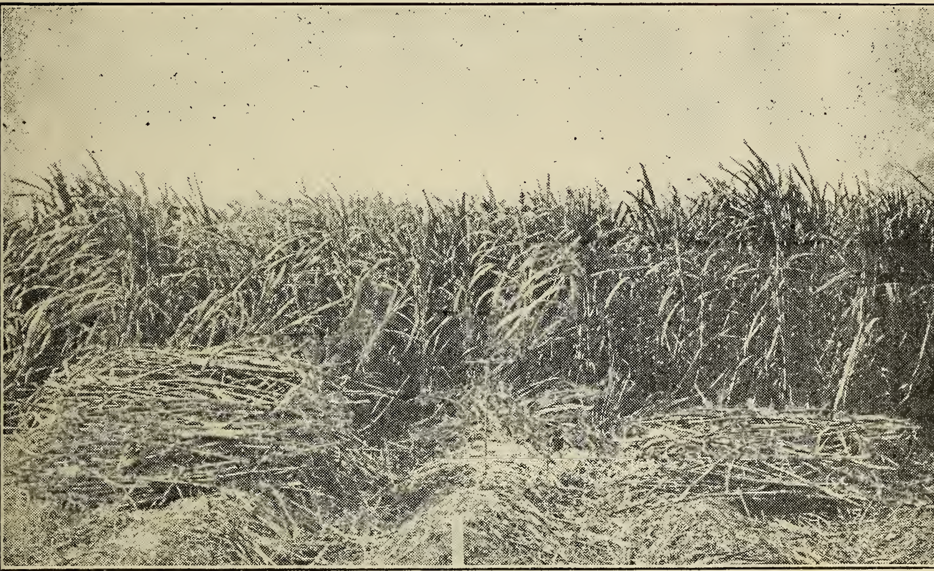
An analysis of the individual transactions in certain local markets on one day revealed the fact that in the commission markets there were numerous inconsistencies and irregularities in the prices received by farmers when these prices were classified according to the grade and staple length designations of government classers. In many cases, farmers received the same price for cotton called a short staple length as for cotton called a longer staple length. There was, usually, a wide range in the prices received for cotton all designated as the same grade and same staple length. Such inconsistencies were largely accounted for in Market A, however, by similar inconsistencies in the grade and staple length designations of government classers and of local buyers. In the merchant markets analyzed, the farmers received about the same price for every bale regardless of its quality or any other consideration, and the level of prices was generally lower in the merchant markets.

In Market A it was found that 82.5 per cent of the failure for central market premiums and discounts for staple length to be reflected in prices received by farmers could be accounted for by the failure of the staple length designations of local buyers to reflect differences in staple length as designated by the government classers. Similar inconsistencies in the classing of cotton by government classers and local buyers were observed in the other local markets for which these data were available.

A definite tendency on the part of the local buyers to call practically all of the cotton as one, two, or three of the middle grades and staple lengths was apparent. On the other hand, the government classers usually made a more or less normal distribution of the cotton throughout the range of grades and staple lengths.

It seems apparent from this study that the type-of-buyers and the degree of competition in a market are very important factors with respect to price quality relationships and average price levels, and that comparability and uniformity of cotton classing are prerequisites for an accurate reflection of quality values to farmers.

SOIL FERTILITY INVESTIGATIONS SUGAR CANE DISTRICT OF LOUISIANA



Effect of nitrogen on sugar cane, Mandalay Field, Houma, Louisiana
Season of 1930

60 pounds of nitrogen per acre	Unfertilized
33.0 tons sugar cane per acre	19.6 tons of sugar cane per acre

LOUISIANA AGRICULTURAL EXPERIMENT STATION
Baton Rouge, La.

SOIL FERTILITY INVESTIGATIONS SUGAR CANE DISTRICT OF LOUISIANA

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INTRODUCTION

The study of the sugar cane soils of Louisiana that is being conducted by the Division of Soil Investigations, U. S. Bureau of Chemistry and Soils in co-operation with the Louisiana Agricultural Experiment Station was planned to furnish the farmers with fundamental facts regarding the needs of their different soil types.

The co-operative field work was started February 5, 1929, and in the following pages all the data pertaining to the different projects are given. Fertility test fields have, up to the present time, been located only on the more extensively developed soils but it is hoped will eventually include the dominant soil types of each of the principal soil areas.

During the early part of the growing season a drought prevented the sugar cane from making as favorable growth as usual. Heavy rains throughout the latter part of the season retarded maturity, All experiments were harvested under favorable weather conditions and the results can be accepted as authentic. IT MUST BE REMEMBERED THAT THESE RESULTS REPRESENT ONLY ONE YEAR'S EXPERIMENTS AND THE BEST MIXTURES MAY VARY SLIGHTLY UNDER DIFFERENT SEASONAL CONDITIONS.

RECONNAISSANCE SURVEY AND PRINCIPAL SOIL AREAS

The reconnaissance survey of the Sugar Cane District of Louisiana was undertaken to determine the extent and distribution of the principal soil areas and the dominant soil types of each. All parts of the cane belt were visited and a great number of borings and pits were made to study the characteristics of the different soils. The soil surveys that had been made by the Division of Soil Survey, U. S. Bureau of Chemistry and Soils, of various parishes were of great help in the work.

The soils of the Sugar Cane District of Louisiana are practically all alluvial in origin. In the days before the protecting levees were built the Mississippi and its tributaries flooded this section periodically. Vast amounts of sediments eroded from the fertile fields further north were deposited according to the whims of the flood waters. Bordering the watercourses and where the currents were swiftest the heavier materials, sand and coarse silt, were dropped whereas back from the channels the stagnant waters gave up their burden of silt and clay. But the clay, silt and sand did not always come from the same part of the watershed and the overflows were often local so that the sediments differ from place to place, depending upon the methods of deposition and the locality from which the alluvium was eroded. On the basis of dominant soil characteristics, therefore, the district has been separated into five major soil divisions: (1) Mississippi Alluvium, First Bottom Soils; (2) Mississippi Alluvium, Terrace Soils; (3) Red River Sediments; (4) Mississippi-Red River Sediments; and (5) Coastal Prairie Sediments of the Gulf Coastal Plain. Plate 1.

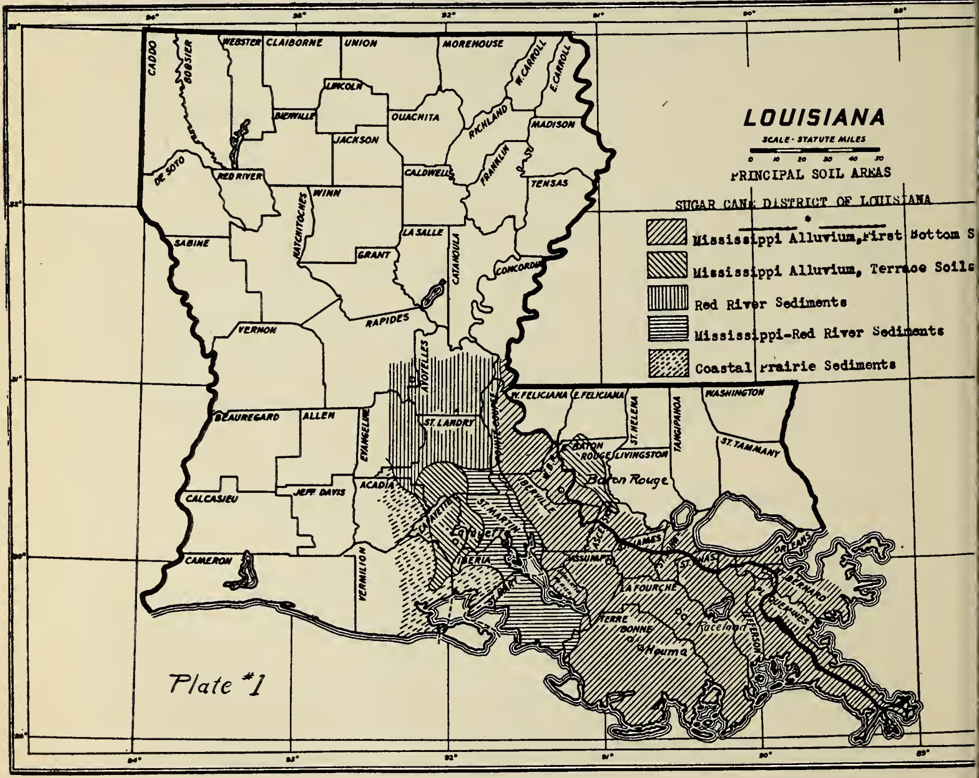

Plate #1

MISSISSIPPI ALLUVIUM, FIRST BOTTOM SOILS: The greater part of the Sugar Cane District of Louisiana falls within the limits of the first major division, Mississippi Alluvium, First

Bottom Soils or includes that part of Louisiana east and south of a line drawn from Morgan City north along the Atchafalaya River to Simmsport, down the east side of the Mississippi to the vicinity of Plaquemine then east to Lake Pontchartrain. The soils are of recent origin and represent, for the most part, alluvium brought down by the Mississippi and its tributaries. Even at the present time the lower sections are receiving sediments from the overflow waters of the smaller streams and from colluvial wash. The most extensively developed soils belong to the Yazoo and Sharkey series or groups of soils.

Yazoo Series: The soils of the Yazoo series are gray, grayish brown to light brown. The subsoils usually consist of a succession of light and heavy textured horizons or layers of a gray or mottled gray, rust brown and pale yellow color. Bluish casts are not uncommon in the heavier layers. Small lime concretions sometimes occur in the subsoil and the dominant soil reaction range is from neutral to alkaline. These soils, locally known as "Sandy Lands," usually occupy the front lands bordering the watercourses. Along the Mississippi River the Yazoo very fine sandy loam is the most extensive type and often extends back from 1 to 2½ miles before it merges with the heavier types. Along the bayous and smaller streams the strips are much narrower. The Yazoo soils occupy higher elevations than the Sharkey and have better drainage. The soils of this series can be handled under wide moisture conditions and their fertility can be easily improved by proper cultural methods.

Sharkey Series: Throughout the lower parts of the bottoms, back nearer the swamps, the soils of the Sharkey series, locally known as "Black Land," predominate. The surface soils are brown to dark brown with gray to bluish gray subsoils that are usually mottled with gray, rust brown and yellow. Drainage is poor and the ground water table is, as a rule, near the surface. These soils are difficult to handle and must be plowed under proper moisture conditions. Clods when exposed to the sun and rain break down into a granular mass. The soils are high in colloidal or extremely fine material and the heavier types have a tendency to run together.

MISSISSIPPI ALLUVIUM, TERRACE SOILS: This soil area consists of two developments, one in the vicinity of Lafayette, which covers the greater part of Lafayette Parish, and the southwestern quarter of St. Landry and the other on the east side of the Mississippi River at Baton Rouge. The general level of these terraces is from 15 to 25 feet above the normal level of the first bottoms. The most extensively developed soils belong to the Lintonia and Olivier series.

Lintonia Series: The surface soils of the Lintonia series are brown to dark brown underlain by heavier textured subsoils of a brown, yellowish brown to pale yellow color. The most extensive type is the silt loam. It has an acid reaction with a range of medium to slightly acid for the surface soil. Drainage is excellent. While the subsoils are retentive of moisture, the top layers dry quickly, a condition that could be improved by the incorporation of green manures.

Olivier Series: The Olivier series has dark brown to dark grayish-brown surface soils and gray or drab subsoils mottled with rust brown and yellow. Small iron concretions occur on the surface and throughout the soil layer. Drainage is not as well established as on the Lintonia silt loam and tiling and open ditches would prove of great help. The soil is not as retentive of moisture as the Lintonia and the sugar cane suffers from drought much earlier in the season. The soils have much the same reaction as the Lintonia silt loam or acid to almost neutral.

RED RIVER SEDIMENTS: North of an imaginary line drawn east and west through Washington or north of Bayou Courtableau the country presents a very different appearance from that to the south. The soils have a reddish cast and plowed fields when wet are brick red to pinkish red. The soils are derived from the Red River sediments that have come down during periods of flood from the Permian Red Beds. Throughout the limited area devoted to the production of sugar cane only first bottom soils occur. The Yahola and Miller series predominate with the Yahola very fine sandy loam occupying the largest total area.

Yahola Series: The soils of the Yahola series are characterized by reddish brown to pinkish red surface soils. The subsoils consists of interbedded layers of varying textures ranging from very fine sandy clay to loamy fine sand. The color of these layers is much the same as that of the surface though light gray mottles occur in the lower part of the three foot section. Both the soil and subsoil show an alkaline reaction. The soils occupy first bottom positions and while many of the fields show good drainage, the type as a whole could be improved by open ditches and tiles. The soils are easy to handle and may be maintained in a high state of productivity by the use of suitable cultural methods.

Miller Series: The surface soils of the Miller series are brownish red to reddish brown underlain by chocolate red to pinkish red heavier textured subsoils. They differ from the Yahola in that the subsoils are not laminated but uniformly heavy. Drainage is somewhat better established. Both soil and subsoil give an alkaline reaction.

MISSISSIPPI-RED RIVER SEDIMENTS: If a line is drawn from Morgan City north along the Atchafalaya River to Krotz Springs, west to the terrace section at Port Barre, south through Cade, Lydia and Glenco, it will outline roughly a section where the soils show an entirely different influence from those east of the Atchafalaya. A close study has shown to date that the sediments are not the same, a fact that has been substantiated by the history of that section. Back in years past it appears that the Teche served as an outlet for the flood waters of the Red River and during periods of overflow deposited sediments burying the original soils, soils that had already reached different stages of development. The result is a section possessing different soil characteristics. Two important groups of soils have been studied to date. These soils have been classified as Pharr and Franklin series.

Pharr Series: The surface soils of the Pharr series are dark gray to dark grayish brown underlain by a grayish brown to almost black heavier textured layer that usually has a thickness of 9 to 12 inches. The true subsoil is a dark gray to gray compact, heavy clay highly mottled with rust brown, yellow and yellowish brown.

Franklin series: The Franklin series has light brown to grayish brown surface soils and mottled gray, yellowish brown and rust brown subsoils. The subsoils usually consists of interbedded light and heavy textured layers but the differences in texture are not as pronounced as in the Yazoo. The subsoils are consistently heavier than the Yazoo and show a different pH reaction.

COASTAL PRAIRIE OF GULF COASTAL PLAIN: A low level plain made up of marine or oceanic deposits occurs west of an imaginary line drawn through the eastern part of Acadia Parish, the western section of Lafayette, the eastern part of Vermilion and the central part of Iberia Parish. Along its western boundary it merges imperceptibly with the terrace section of the Mississippi basin. The general level is below that of the terrace and the section, as a whole, has poor drainage. The principal soil series of the limited section studied are the Crowley and Lake Charles.

Crowley Series: The soils of the Crowley series consists of brown to grayish brown top layers underlain at 7 to 9 inches by a light gray rather pulvurulent horizon. The subsoil is moderately tough, plastic clay of a dark drab to dark gray color mottled with red, reddish yellow, yellowish brown and yellow. Typically the red mottles increase with depth and the texture becomes somewhat lighter. Surface drainage is good but the subsoil is poorly drained and shows the lack of thorough aeration.

Lake Charles Series: The surface soils of the Lake Charles series are dark brown to very dark grayish brown. The subsoils are heavy and range in color from dark brown mottled with gray, rust brown and yellow to mottled gray and yellow. The yellow mottles usually increase with depth. The subsoils are highly calcareous and a concentration of lime concretions occurs at from 22 to 28 inches below the surface. The surface of this soil is flat to gently sloping and natural drainage is poor.

WEATHER RECORDS, SEASON OF 1930

The weather records for the season of 1930 show that January was exceedingly wet over the entire district with Cinclare giving the highest precipitation and Bunkie the lowest. The mean temperatures for March, at each of the weather stations, are lower than for February which was reflected in the low germination of the sugar cane. In April and May the high mean temperatures caused rapid succering but the lack of moisture during the months of May and June prevented normal growth. Except at the Mandalay Field, near Houma, where a light rain fell immediately after the fertilizer had been applied, very little response to fertilizers was observed until the last of June or first of July. During August and September which normally is a period when sugar cane starts to mature, high precipitation and fairly high temperatures encouraged growth even up to harvest.

The temperature and precipitation data at Houma, Lafayette, Cinclare and Bunkie, points at widely separated sections of the sugar cane district of Louisiana, are given in Tables 1 to 4.

TABLE 1

LAFAYETTE

(Year of 1930)

Month	TEMPERATURE Max.	Min.	Mean	Rainfall Inches	Number of Precipitation
January	61.4	42.1	51.8	8.68	9
February	72.2	50.0	61.1	4.29	9
March	67.8	47.9	57.8	3.27	12
April	84.8	57.9	70.2	1.37	4
May	85.2	66.3	75.8	3.58	9
June	93.4	66.1	79.8	.36	5
July	94.3	70.8	82.6	9.04	14
August	92.3	69.8	81.0	6.02	12
September	88.5	68.3	78.4	9.41	13
October	79.7	56.7	68.2	5.77	8
November	70.3	49.6	60.0	5.32	12
December	60.6	40.5	50.6	3.86	10

TABLE 2

HOUMA

Month	TEMPERATURE Max.	Min.	Mean	Rainfall Inches	Number of Precipitation
January	56.9	44.1	50.6	8.88	4
February	67.1	50.1	58.6	2.84	5
March	63.3	49.5	56.3	3.16	10
April	76.7	55.2	66.0	3.03	3
May	79.8	66.3	73.0	1.20	1
June	84.0	65.1	74.4	.84	5
July	85.3	70.2	77.8	8.77	11
August	83.6	68.3	76.0	6.23	9
September	81.5	69.7	75.6	8.92	15
October	74.9	57.6	66.2	5.42	10
November	64.9	50.1	57.5	5.93	8
December	55.9	40.5	48.1	3.17	6

TABLE 3
CINCLARE
(Year of 1930)

Month	TEMPERATURE Max.	Min.	Mean	Rainfall Inches	Number of Precipitation
January	60.7	41.9	51.3	10.21	8
February	70.6	48.0	59.3	2.72	7
March	65.9	47.7	56.8	5.16	11
April	79.6	56.5	68.0	1.83	4
May	82.8	65.7	74.2	6.34	7
June	91.5	66.5	79.0	0.00	0
July	94.4	69.9	82.2	6.02	10
August	92.4	68.6	80.5	5.30	12
September	87.5	67.6	77.6	7.10	12
October	80.0	55.0	67.5	2.40	6
November	70.6	47.9	59.2	6.86	12
December	60.2	38.5	49.4	2.79	7

TABLE 4
(Cheneyville)
BUNKIE

Month	TEMPERATURE Max.	Min.	Mean	Rainfall Inches	Number of Precipitation
January	61.5	38.8	50.2	6.36	7
February	71.0	47.5	59.2	3.59	5
March	68.0	45.6	56.8	2.84	5
April	83.3	55.5	69.4	.63	3
May	83.5	64.6	74.0	4.54	6
June	93.0	64.1	78.6	.58	1
July	97.0	69.5	83.2	1.72	4
August	95.0	69.5	82.2	1.54	6
September	88.8	67.6	78.2	8.44	14
October	80.1	54.4	67.2	2.92	5
November	70.2	46.1	58.2	6.92	6
December	59.7	38.4	49.0	5.42	3

FERTILIZER TEST FIELDS

In undertaking the problem of sugar cane production in Louisiana it seems logical to determine the fertilizer requirements of each of the principal soil areas where the dominant soil characteristics are different. Such a study is necessarily slow due to the extent of the district and for the present includes only a few of the soils; Yazoo very fine sandy loam, Lintonia silt loam and Yahola very fine sandy loam. These soils are described on pages 7 and 8, respectively.

The 1930 program included nine fertility test fields situated at widely separated sections of the Sugar Cane District. Three of the 1929 experiments, located near Houma, Raceland and Bunkie, that remained in cane were continued and fertilized with five combinations of the principal plant food elements, nitrogen, phosphoric acid and potash at the following rates in pounds per acre: 40 pounds of nitrogen, 20 pounds of phosphoric acid and 20 pounds of potash; 40 pounds of nitrogen and 20 pounds of phosphoric acid; 40 pounds of nitrogen and 20 pounds of potash; 20 pounds of phosphoric acid and 20 pounds of potash; and 40 pounds of nitrogen. The tests at Houma and Raceland located on Yazoo very fine sandy loam (page 4) were replicated four times, whereas the Bubenzer Field, Bunkie, on Yahola very fine sandy loam (page 5) consists of one set of plots that run the entire length of the square. In addition to the above, six new fields were located near the following towns, Cinclare, Donaldsonville, Raceland, Houma and Lafayette. Five of these were laid out according to the Triangle System[a] or where 21 different mixtures of nitrogen, phosphoric acid and potash are applied at the rate of 60 pounds of plant food per acre. The sixth field consists of a rate and source study where 20, 40, 60 and 80 pounds of nitrogen from the carriers Ammonium Sulphate, Cyanamid, Calcium Nitrate, Calurea and Nitrate of Soda were replicated twice. With the exception of the field near Lafayette which was located on Lintonia silt loam (page 8), all the new projects are located on Yazoo very fine sandy loam (page 7).

(a) The Triangle System of Fertilizer Experimentation is explained fully in an article by Oswald Schreiner and J. J. Skinner in Jour. Amer. Scc. of Agronomy, Vol. 10 ps 225-246. (1922).

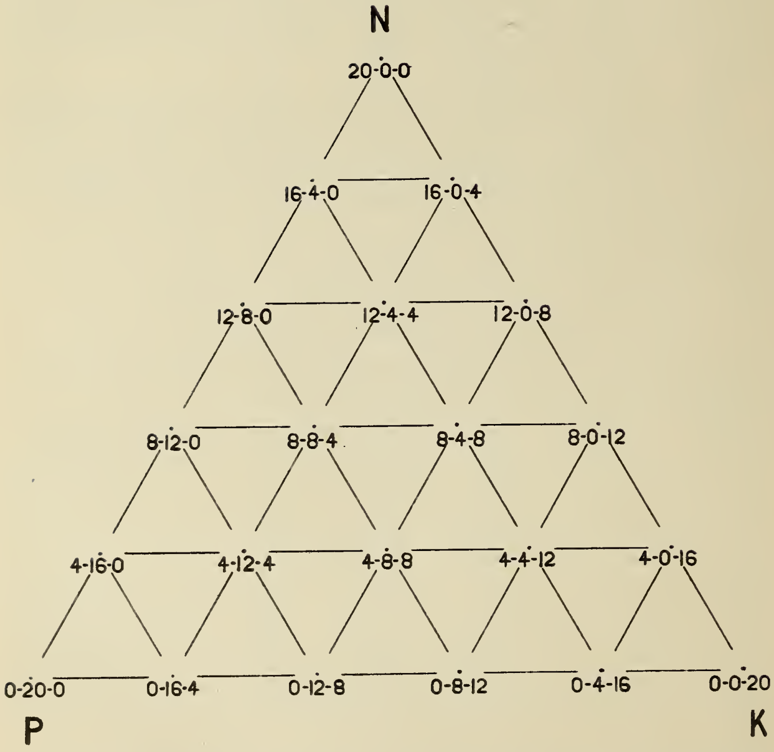

PLATE 2—Triangle diagram with points representing the 21 fertilizer combinations, expressed in percentages used in these experiments.

The five new fields were planned and laid out to study the effect of 21 different combinations of the three plant food elements: nitrogen, phosphoric acid and potash. The basis of interpretation of this system is an equilateral triangle, Plate 2, in which the extreme points represent the single elements nitrogen (N), phosphoric acid (P_2O_5) and potash (K_2O). In the triangle diagram nitrogen is placed at the top, phosphoric acid at the left and potash at the right. Each side of the triangle is divided into five equal parts and lines drawn connecting these points. The points of intersection represent the fertilizer mixtures used on the plots.

In Plate 2 the points on the line forming the base of the triangle represent the mixtures containing no nitrogen. The sides, in like manner, represent mixtures free of phosphoric acid and potash. Moving from the base toward the apex each succeeding parallel line represents a 4 per cent increase in nitrogen whereas the lines parallel to the sides show corresponding 4 per cent increaments of phosphoric acid and potash. In other words the points inside the triangle represent complete fertilizer mixtures.

In order to facilitate the interpretation of the results the yields of sugar and the tons of sugar cane per acre are shown on diagrams similar to Plate 2.

An examination of the analysis given in Plate 2 shows that each of the mixtures add to a total of 20 per cent but no two are alike. In other words each plot received the same number of pounds of plant food constituents, but each received a different ratio.

All fertilizer formulas in this publication are stated in the following order: nitrogen, phosphoric acid and potash. The source of the different plant food constituents are: nitrogen from nitrate of soda, phosphoric acid from superphosphate and potash from muriate of potash.

FIELD PROCEDURE

In the spring of 1930 sites for the fertilizer test fields were selected with the following points in mind: importance of the soil to be studied, uniformity of soil type and regularity of sugar cane stand. At each location a great number of borings were made, with a three foot soil auger, to determine if all soil characteristics were sufficiently uniform. In no case was the fertilizer applied unless the stand of sugar cane was healthy and uniform. The plots were designed and laid out so that in all cases a four row heap, protected on each side by buffers that had received the same mixtures, would give approximately one good wagon load. The average size of plots was 8 rows wide and 110 feet long.

The fertilizer was applied in the spring by hand. It was broadcast over the loose dirt near the off-barred furrow so that when this dirt was thrown back to the cane it would be thoroughly mixed with the top soil that would first receive the new roots. Application was made under the personal supervision of the authors. In the case of the Bubenzer Field the fertilizer was applied with a single row drill which was calibrated for each mixture.

During the growing season periodical observations were made and in order that the knowledge of the mixtures might not influence notations, the plots were numbered serially.

Samples of sugar cane from each plot of the various test fields were collected within a ten-day period and trucked to the Houma Station where they were ground and analyzed within 24 hours after being cut. The mill setting remained uniform during this period. Great care was exercised in collecting the samples from the plots and this operation was personally supervised. With the average condition of each plot in mind, random stools were selected from which equal numbers of good, medium and bad canes were selected in the proportion in which they occurred. This procedure continued until 60 to 80 pounds of sugar cane had been cut. The canes were then carried to the headland where they were stripped and topped by the same man, tied in bundles and tagged.

The cutting and weighing of the plots followed immediately upon completion of the mill analysis. Only the four middle rows of each plot were harvested thus leaving two buffer rows to take care of any carry over effect.

SUGAR CALCULATIONS

The 96 per cent sugar per ton of sugar cane was calculated by the Winter-Carp formula (d).

$$X = \left| \frac{S\left(1.4 - \dfrac{40}{P}\right)}{.96} \right| - 20$$

Where X = Pounds of 96 per cent sugar per ton of cane
S = Per cent sucrose in crusher juice
P = Purity of crusher juice

The following factors being included in the calculations (d)

78 per cent—Extraction
100 per cent—Boiler house efficiency
.92 per cent—Observed sucrose—Normal sucrose
.954 per cent—Observed brix—Normal brix

(d) U. S. D. A. Circular No. 418 R. D. Rands and S. F. Sherwood.

CINCLARE FIELD

Cinclare, La.

TABLE 5—Effect of the different ratios of plant food elements applied at the rate of 60 pounds of plant food constituent per acre, on P.O.J. 36 2nd. year stubble cane.

Fertilizer N P K	Station Mill Analyses			Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre	Rank
	Brix	Sucrose	Purity				
20– 0– 0	15.80	12.57	79.56	16.0	165.0	2,640	10
16– 4– 0	14.57	10.80	74.13	18.6	135.7	2,524	11
16– 0– 4	13.70	9.44	68.91	16.0	112.6	1,802	18
12– 8– 0	14.47	10.48	72.42	18.7	129.6	2,424	12
12– 4– 4	14.57	10.65	73.10	20.0	132.7	2,654	9
12– 0– 8	15.60	12.47	79.94	18.0	164.2	2,956	4
8–12– 0	15.27	11.68	76.49	21.0	149.8	3,146	3
8– 8– 4	14.80	11.03	74.53	19.5	139.1	2,712	6
8– 4– 8	15.40	12.76	82.86	15.8	173.6	2,710	7
8– 0–12	13.97	9.86	70.58	15.0	120.1	1,802	18
4–16– 0	14.37	10.58	73.63	15.0	132.0	1,980	13
4–12– 4	15.00	11.61	77.40	29.0	149.9	4,347	1
4– 8– 8	14.90	12.01	80.61	17.0	158.9	2,701	8
4– 4–12	15.33	11.95	77.95	12.0	155.3	1,864	15
4– 0–16	15.50	12.89	83.16	17.0	173.6	2,951	5
0–20– 0	14.80	11.03	74.53	11.5	139.1	1,600	21
0–16– 4	14.27	10.35	72.53	14.2	128.2	1,820	17
0–12– 8	14.60	11.42	78.22	13.0	148.4	1,929	14
0– 8–12	14.17	10.32	72.83	25.0	128.2	3,205	2
0– 4–16	14.87	11.41	76.73	11.0	146.5	1,611	20
0– 0–20	14.67	11.12	74.77	13.0	141.6	1,841	16
Average of four Check Plots	14.77	11.21	75.89	12.5	143.1	1,789	19

Fertilizer applied April 29th, 1930. Sugar cane harvested December 1st and 2nd, 1930.

CINCLARE FIELD

Yazoo Very Fine Sandy Loam

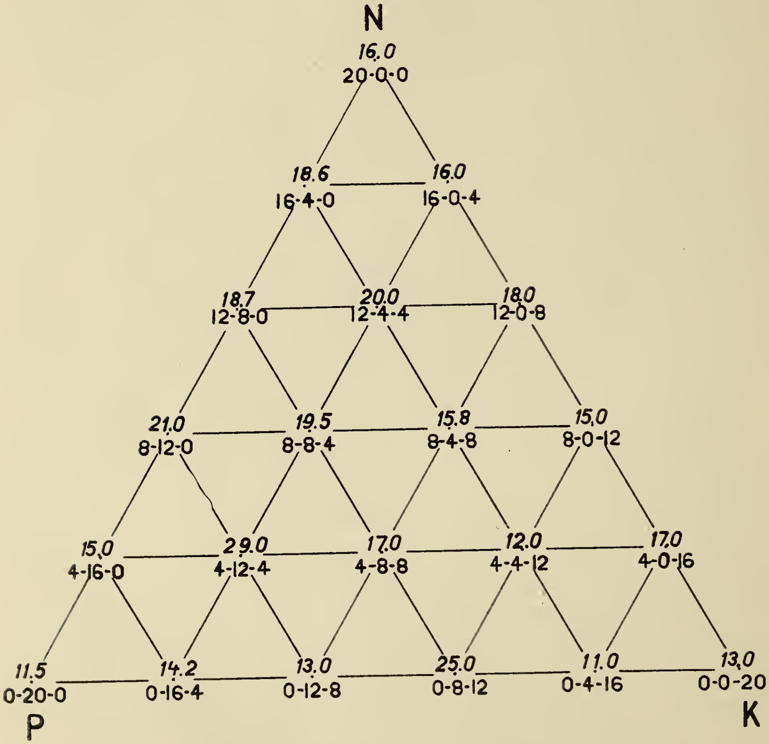

PLATE 3—Tons of cane per acre. Average of check plots 12.5 tons.

CINCLARE FIELD

Yazoo Very Fine Sandy Loam

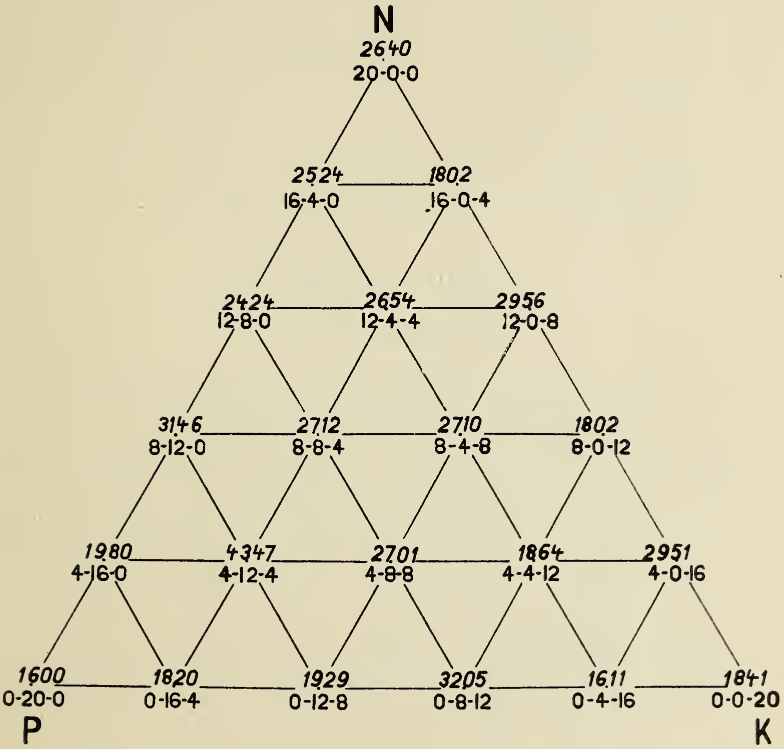

PLATE 4—Pounds of sugar per acre. Average of check plots 1,789 pounds.

In Table 5 are given the results obtained with sugar cane during the season of 1930 whereas Plates 3 and 4 show graphically the yields in tons and sugar per acre.

In Plate 3 it will be noticed that the 4-12-4 plot made the highest yield. The 8-12-0 and 8-8-4 gave moderately high returns whereas all the points on the 12 per cent nitrogen line are consistently high. With the exception of the 0-8-12 plot all the nitrogen free mixtures gave low yields.

The yields in sugar per acre, Plate 4, shows practically the same trend as tonnage. The 4-12-4 plot gave the highest yield whereas the 8-12-0 was third. The mixtures containing 12 per cent of nitrogen are consistently high but the highest point of the line is plot 12-0-8 instead of 12-4-4. The 0-8-12 plot gave the second highest yield but when compared with the other nitorgen free mixtures which are low is apparently out of line.

BELLE TERRE FIELD

Donaldsonville, La.

TABLE 6—Effect of the different ratios of plant food elements applied at the rate of 60 pounds of plant food constituents per acre, on P.O.J. 213 1st. year stubble cane.

Fertilizer N P K	Station Mill Analyses Brix	Sucrose	Purity	Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre	Rank
20– 0– 0	14.31	10.48	73.24	31.3	130.9	4,097	2
16– 4– 0	14.91	12.01	80.55	22.2	158.9	3,528	12
16– 0– 4	15.38	12.47	81.08	25.5	165.6	4,223	1
12– 8– 0	14.88	11.56	77.69	23.8	149.6	3,560	11
12– 4– 4	15.21	12.05	79.23	23.3	157.9	3,679	9
12– 0– 8	14.51	11.34	78.45	21.8	147.4	3,213	14
8–12– 0	15.51	12.59	81.18	22.2	167.4	3,716	7
8– 8– 4	15.61	12.76	81.74	22.2	170.3	3,780	5
8– 4– 8	14.31	10.83	75.68	26.9	138.0	3,712	8
8– 0–12	16.18	13.76	85.04	21.7	187.5	4,069	3
4–16– 0	14.71	11.36	77.23	19.5	146.6	2,859	18
4–12– 4	15.21	12.35	81.20	22.9	164.2	3,760	6
4– 8– 8	15.58	12.91	82.87	21.2	173.2	3,672	10
4– 4–12	15.81	13.15	83.18	22.5	177.2	3,987	4
4– 0–16	15.11	12.00	79.42	18.2	157.4	2,865	17
0–20– 0	15.21	12.15	79.88	20.4	160.0	3,264	13
0–16– 4	15.91	13.35	83.91	16.0	180.7	2,891	16
0–12– 8	15.36	12.56	81.78	16.5	167.8	2,769	19
0– 8–12	15.21	12.42	81.66	16.3	165.6	2,699	21
0– 4–16	15.41	12.44	80.73	18.8	164.8	3,098	15
0– 0–20	15.41	12.64	82.03	14.9	169.0	2,518	22
Average of six Check plots............	15.16	12.24	80.74	16.6	163.0	2,706	20

Fertilizer applied April 14th, 1930. Sugar Cane harvested December 5th and 6th, 1930.

BELLE TERRE FIELD

Yazoo Very Fine Sandy Loam

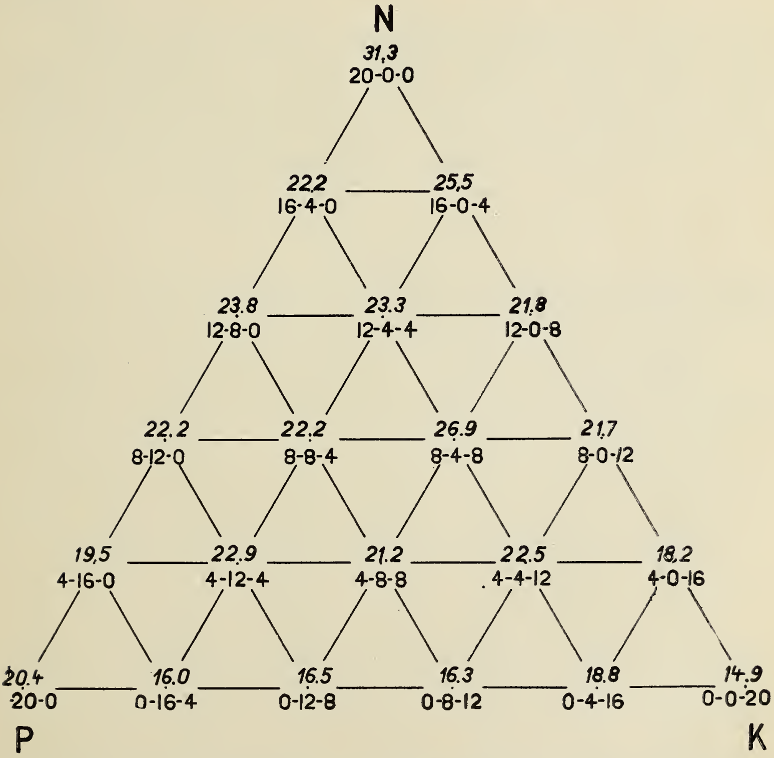

PLATE 5—Tons of cane per acre. Average of check plots 16.6 tons.

BELLE TERRE FIELD

Yazoo Very Fine Sandy Loam

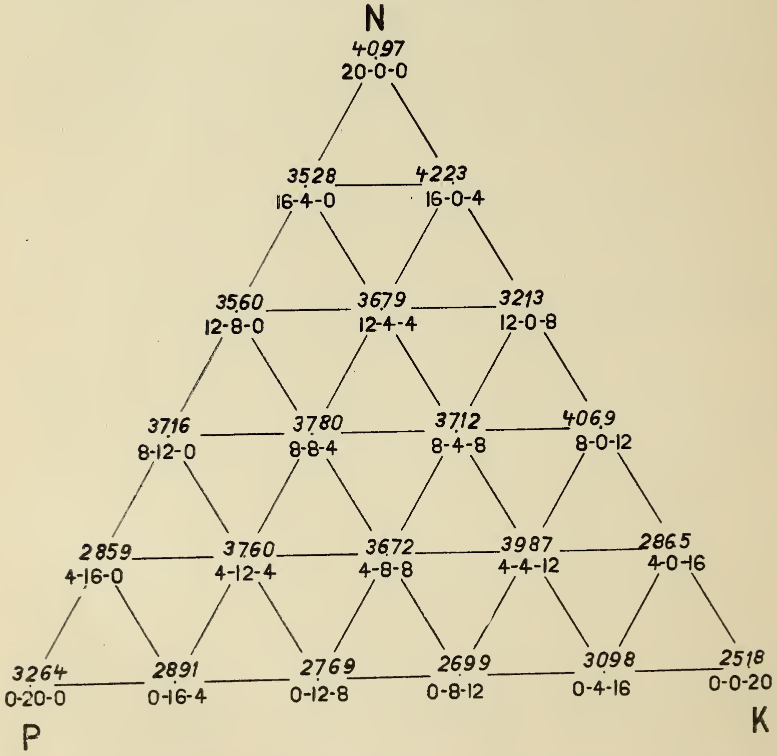

PLATE 6—Pounds of sugar per acre Average of check plots 2,706 pounds.

The results for the Belle Terre Field, located near Donaldsonville, Louisiana, are given in Table 6 and shown graphically in Plates 5 and 6.

The greater number of high yielding plots, Plate 5, tend to group themselves around plot 8-4-8 which shows a tonnage of 26.9. It is interesting to note that the high nitrogen plot, 20-0-0, gave an even greater yield, 31.3 tons, and that the increase along the nitrogen-potash line is steady with each 4 per cent nitrogen increment.

In Plate 6 the center of the greatest number of high yielding plots is at plot 8-8-4 though three plots of even higher yields occur on the nitrogen-potash line at 8-0-12, 16-0-4 and 20-0-0. The yields on the nitrogen-potash line are consistently higher than those on the nitrogen-phosphoric acid line.

UPPER TEN FIELD

Raceland, La.

TABLE 7—Effect of the different ratios of plant food elements applied at the rate of 60 pounds of plant food constituent per acre, on P.O.J. 213 1st year stubble cane.

Fertilizer N P K	Station Mill Analyses			Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre	Rank
	Brix	Sucrose	Purity				
20– 0– 0	14.49	11.61	80.13	27.4	153.0	4,192	5
16– 4– 0	13.46	9.88	73.40	26.3	123.6	3,251	16
16– 0– 4	15.49	12.86	83.02	26.1	172.8	4,510	2
12– 8– 0	14.96	12.20	81.55	26.7	162.6	4,341	4
12– 4– 4	16.29	13.92	85.45	27.0	190.2	5,135	1
12– 0– 8	13.83	10.29	74.41	29.0	129.8	3,764	8
8–12– 0	15.53	11.00	70.84	24.0	133.8	3,211	17
8– 8– 4	14.36	11.24	78.27	23.4	146.1	3,418	12
8– 4– 8	14.87	12.15	81.71	27.0	162.1	4,376	3
8– 0–12	15.16	12.37	81.60	20.0	164.8	3,296	15
4–16– 0	15.56	13.04	83.81	20.4	176.4	3,599	9
4–12– 4	15.36	12.79	83.26	20.4	172.5	3,519	10
4– 8– 4	15.56	12.99	83.48	21.8	175.7	3,830	7
4– 4–12	15.79	13.35	84.55	18.9	181.4	3,428	11
4– 0–16	15.99	13.95	87.24	20.2	192.8	3,880	6
0–20– 0	15.46	12.86	83.18	19.2	173.3	3,327	14
0–16– 4	14.64	11.79	80.53	19.6	156.1	3,060	18
0–12– 8	15.26	12.40	81.26	18.0	164.9	2,968	19
0– 8–12	16.19	13.92	85.97	17.7	190.9	3,379	13
0– 4–16	15.44	13.01	84.26	14.6	176.6	2,578	21
0– 0–20	14.06	11.07	76.10	15.9	144.2	2,293	22
Average of 7 Check Plots............	15.26	12.55	82.24	17.2	168.1	2,891	20

Fertilizer applied April 8th, 1930. Sugar cane harvested November 12th, 1930.

UPPER TEN FIELD

Yazoo Very Fine Sandy Loam

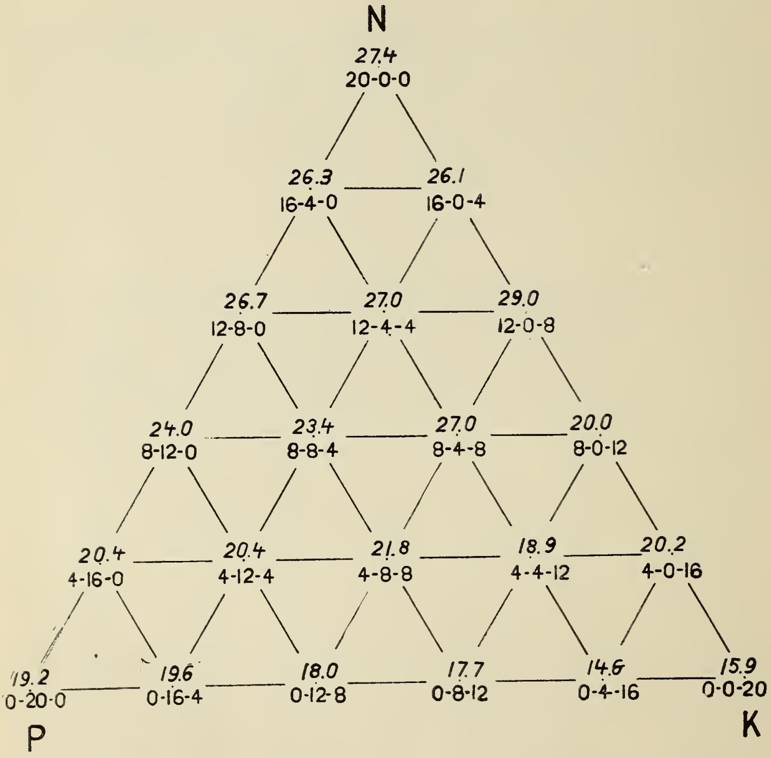

PLATE 7—Tons of cane per acre. Average of check plots 17.2 tons.

UPPER TEN FIELD

Yazoo Very Fine Sandy Loam

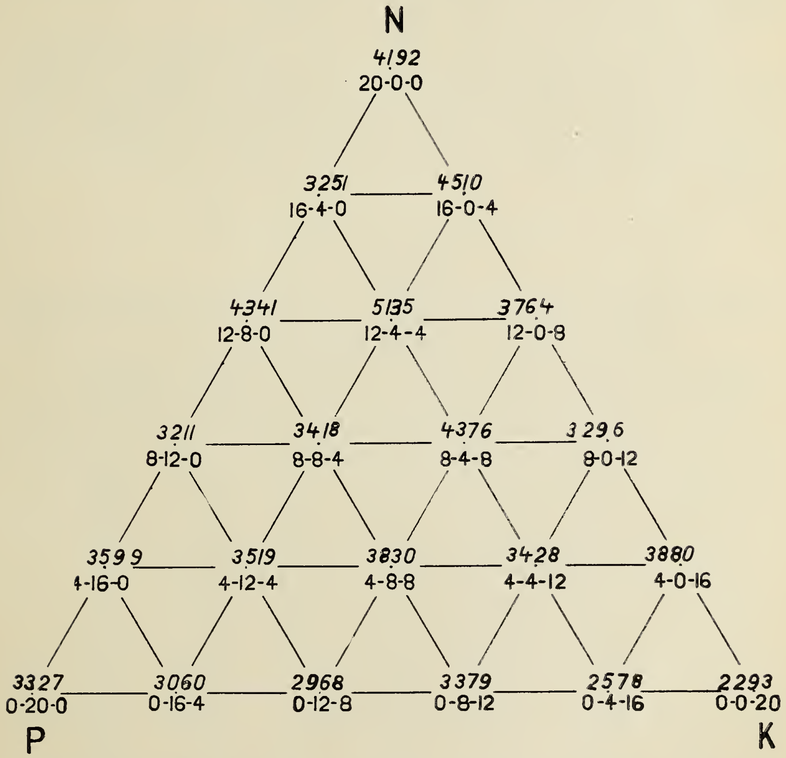

PLATE 8—Pounds of sugar per acre. Average of check plots 2,891 pounds.

The highest yields of sugar cane in tons per acre were produced by the high nitrogen mixtures found in the nitrogen end of the triangle, Plate 7. The main center of highest yields is located at the 12-0-8 plot, though the greater number of high yielding plots seem to group themselves more closely around the 12-4-4 point where the total yield is 2 tons less. The average yields in tons per acre of the phosphoric acid-potash line from the base to the apex are 17.4, 20.8, 23.8, 27.5, 26.2 and 27.4. This shows a steady increase up to the 12 per cent nitrogen line beyond which there is practically no change.

In Plate 8 which gives in graph form the pounds of sugar per acre, the high yielding plots group themselves definitely around the 12-4-4 plot or very near the nitrogen end of the triangle. The mixtures that contain no nitrogen gave rather consistenly low yields.

MANDALAY FIELD

Houma, La.

TABLE 8—Effect of the different ratios of plant food elements applied at the rate of 60 pounds of plant food constituent per acre, on P.O.J. 213 1st. year stubble cane.

Fertilizer N P K	Station Mill Analyses			Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre	Rank
	Brix	Sucrose	Purity				
20– 0– 0	14.50	11.05	76.21	33.0	141.3	4,663	11
16– 4– 0	15.75	12.92	82.04	31.8	172.5	5,486	3
16– 0– 4	15.10	12.07	79.94	30.6	158.9	4,862	9
12– 8– 0	15.73	13.05	82.96	33.2	175.6	5,830	1
12– 4– 4	16.44	14.10	85.77	29.2	193.3	5,644	2
12– 0– 8	15.72	12.47	79.33	30.2	163.5	4,938	7
8–12– 0	16.60	14.23	85.72	27.8	195.0	5,421	4
8– 8– 4	15.88	13.42	84.51	25.0	182.1	4,553	12
8– 4– 8	16.17	13.60	84.11	26.8	184.4	4,942	6
8– 0–12	16.27	13.85	85.12	27.3	188.9	5,157	5
4–16– 0	16.36	13.94	85.21	22.7	190.4	4,322	15
4–12– 4	16.57	14.15	85.39	23.1	193.6	4,472	14
4– 8– 8	16.33	14.01	85.80	25.4	192.1	4,879	8
4– 4–12	16.00	13.41	83.81	24.8	181.4	4,499	13
4– 0–16	16.26	13.79	84.81	25.7	187.8	4,826	10
0–20– 0	16.28	13.82	84.89	21.8	188.2	4,103	18
0–16– 4	16.33	13.83	84.69	22.6	188.2	4,253	17
0–12– 8	16.22	13.85	85.38	22.7	189.3	4,299	16
0– 8–12	16.17	13.53	83.67	22.0	183.0	4,026	19
0– 4–16	15.75	13.17	83.62	21.9	178.0	3,898	20
0– 0–20	16.42	13.90	84.65	20.6	189.2	3,898	20
Average of 14 Check Plots............	16.11	13.56	84.17	20.8	183.9	3,825	21

Fertilizer applied April 10th and 11th, 1930. Sugar cane harvested November 24th and 25th, 1930.

MANDALAY FIELD

Yazoo Very Fine Sandy Loam

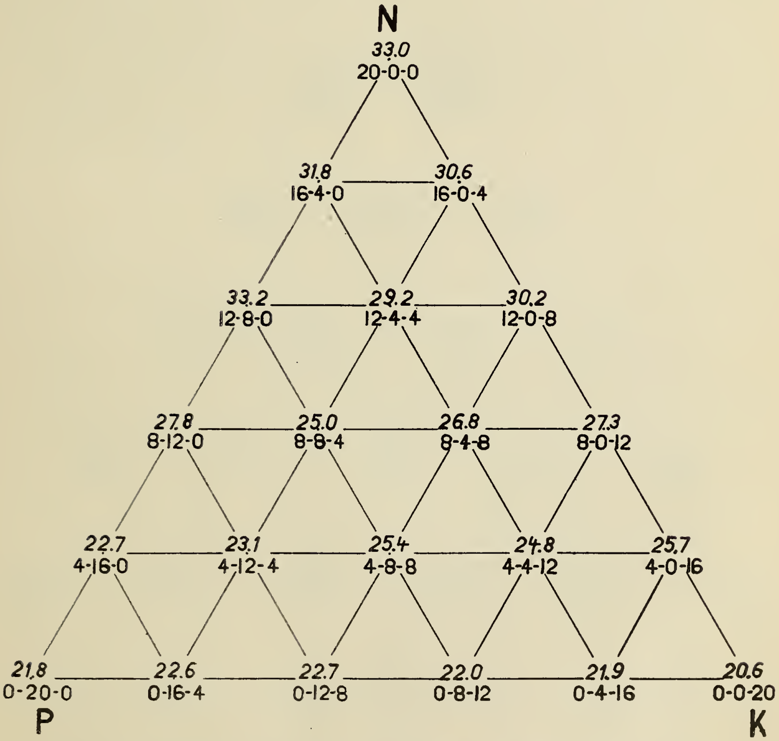

PLATE 9—Tons of cane per acre. Average of check plots 20.8 tons.

MANDALAY FIELD

Yazoo Very Fine Sandy Loam

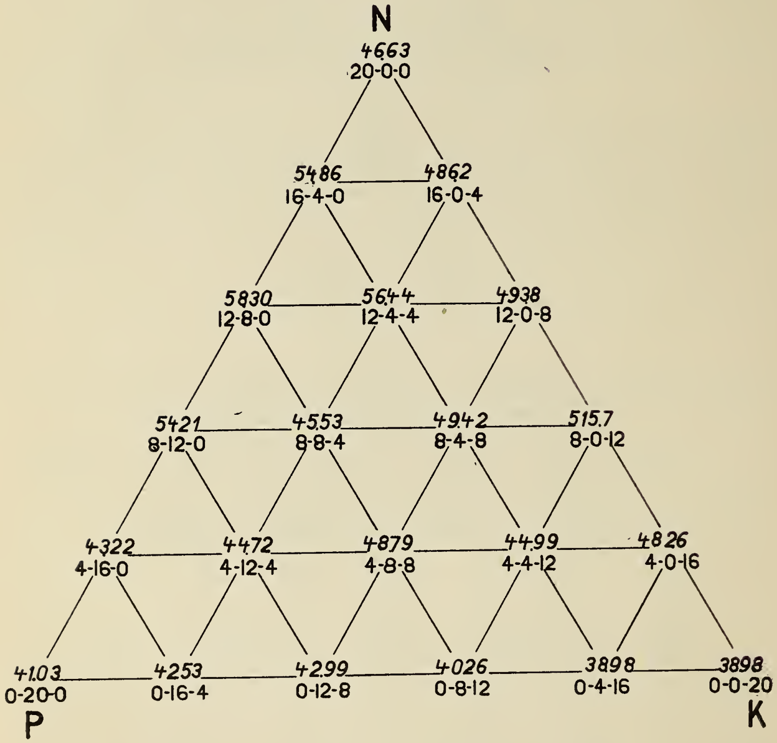

PLATE 10—Pounds of sugar per acre. Average of check plots 3,825 pounds.

In Table 8 are given all the data obtained at the Mandalay Test Field during the season of 1930 whereas Plates 9 and 10 show in graph form yields in tons of sugar cane per acre and pounds of sugar per acre, respectively.

In Plate 9 all the high yielding plots occur in the nitrogen end of the triangle. The 12-8-0 mixture made the greatest return. All the mixtures containing less than 12 per cent nitrogen gave low yields.

The yields in pounds of sugar per acre, Plate 10, gave a more definite trend. Most of the high yielding plots center around the 12-4-4 plot whereas the high yield is at the 12-8-0 plot. The low nitrogen and nitrogen free mixtures gave consistently low yields. It is interesting to note that an application of 60 pounds of nitrogen per acre produced 33 tons of sugar cane but only 4,663 pounds of sugar.

ROY FIELD

Lafayette, La.

TABLE 9—Effect of the different ratios of plant food elements applied at the rate of 60 pounds of plant food constituent per acre, on P.O.J. 213 1st year stubble cane.

Fertilizer	Station Mill Analyses			Tons Cane	Pounds Sugar	Pounds Sugar	
N P K	Brix	Sucrose	Purity	Per Acre	Per Ton	Per Acre	Rank
20– 0– 0	15.29	12.18	79.66	33.2	160.0	5,312	1
16– 4– 0	15.80	13.30	84.18	29.4	180.3	5,300	2
16– 0– 4	15.59	12.91	82.81	28.8	173.4	4,994	3
12– 8– 0	15.35	12.49	81.37	26.6	166.2	4,421	6
12– 4– 4	15.20	12.18	80.13	26.5	160.6	4,256	8
12– 0– 8	15.33	12.49	81.47	28.7	166.3	4,773	4
8–12– 0	15.19	12.33	81.17	19.6	163.8	3,210	13
8– 8– 4	15.59	13.01	83.45	20.2	175.5	3,545	10
8– 4– 8	15.09	12.08	80.06	27.0	159.1	4,296	7
8– 0–12	15.49	12.61	81.41	27.5	167.8	4,614	5
4–16– 0	15.19	12.25	80.64	20.0	162.1	3,242	12
4–12– 4	15.59	13.04	83.65	17.1	176.1	3,011	15
4– 8– 8	15.59	12.84	82.36	16.6	172.0	2,855	16
4– 4–12	15.27	12.54	82.12	18.5	167.8	3,104	14
4– 0–16	15.69	13.18	84.01	21.8	178.5	3,891	9
0– 0–20	15.83	13.31	84.08	14.5	180.3	2,614	18
0–16– 4	15.39	12.76	82.91	13.8	171.5	2,367	22
0–12– 8	15.83	13.29	83.95	13.9	179.9	2,501	20
0– 8–12	15.57	12.96	83.24	14.4	174.7	2,516	19
0– 4–16	15.49	12.84	82.89	14.2	172.6	2,451	21
0– 0–20	15.59	13.01	83.45	20.0	175.5	3,510	11
Average of four Check Plots............	15.25	12.57	82.42	16.8	168.5	2,831	17

Fertilizer applied May 2nd, 1930. Sugar cane harvested November 19th, 1930.

ROY FIELD

Lintonia Silt Loam

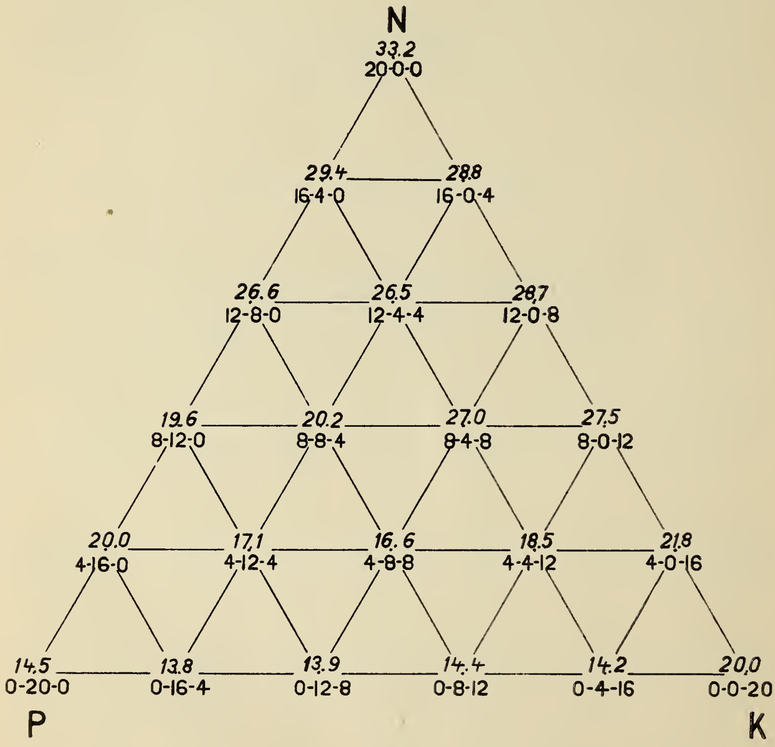

PLATE 11—Tons of cane per acre. Average of check plots 16.8 tons.

ROY FIELD

Lintonia Silt Loam

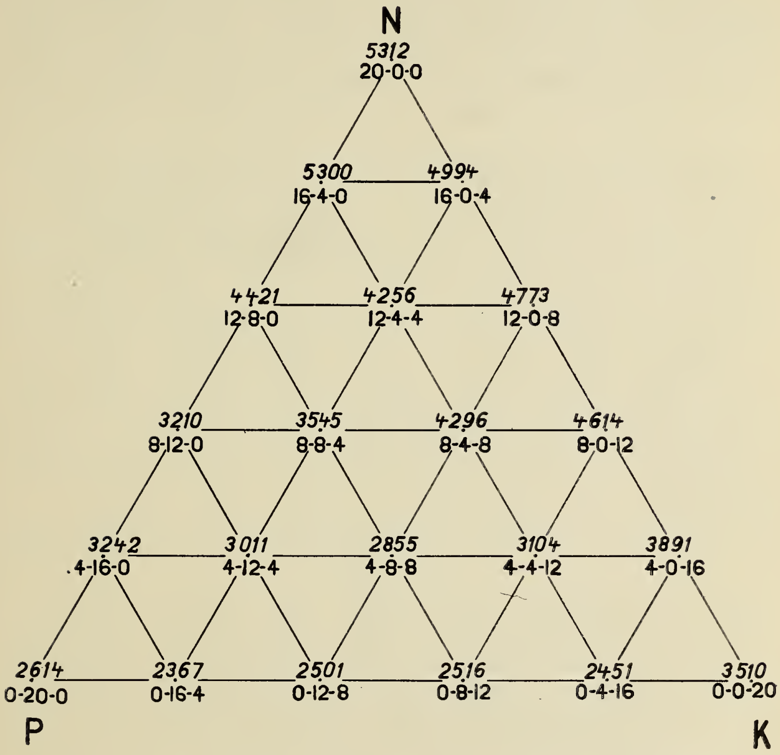

PLATE 12—Pounds of sugar per acre. Average of check plots 2,831 pounds.

In Plate 11 the tons of sugar cane produced on the Roy Test Field, Lafayette, Louisiana, are shown graphically whereas Plate 12 gives the pounds of sugar per acre. Table 9 gives the mill analyses, tons of sugar cane per acre, pounds of sugar per acre, and the rank of the different mixtures.

In Plate 11 the trend of the high yielding plots is very definitely towards the nitrogen end, plot 20-0-0. The greater number of high yields occur on the nitrogen-potash line, where no phosphoric acid was used, the yield increasing as the nitrogen increased. There is one exception to this that is rather marked, namely, the second highest yield at the 16-4-0 plot.

The diagram showing pounds of sugar per acre, Plate 12, has practically the same trend as the tonnage. The greater number of high yielding plots are found on the nitrogen-potash line with straight nitrogen showing the highest yield. As in Plate 11 the second highest yield occurs at the 16-4-0 plot.

TABLE 10—Bubenzer Field, P.O.J. 36 1st. year stubble.

Pounds of Plant Food Constituent Per Acre N P K	Station Mill Analyses			Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre	Rank
	Brix	Sucrose	Purity				
40–20–20	14.99	10.63	70.91	26.4	129.5	3,419	5
40–20– 0	14.29	9.77	67.95	26.3	115.8	3,046	6
40– 0–20	14.79	10.85	73.36	26.6	135.3	3,598	4
0–20–20	16.17	12.66	78.29	24.8	164.8	4,087	1
40– 0– 0	14.99	10.86	72.40	27.1	134.4	3,642	3
0– 0– 0	15.59	11.78	76.20	24.5	149.9	3,675	2

TABLE 11—Ellendale Field, P.O.J. 213 1st. year stubble.

Pounds of Plant Food Constituent Per Acre N P K	Station Mill Analyses			Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre	Rank
	Brix	Sucrose	Purity				
40–20–20	15.61	12.66	81.10	28.7	168.2	4,842	1
40–20– 0	15.39	12.38	80.40	27.8	163.6	4,548	4
40– 0–20	15.50	12.71	82.00	28.2	169.8	4,788	2
0–20–20	15.47	12.76	82.48	20.7	171.1	3,542	5
40– 0– 0	15.68	12.99	82.97	27.4	174.7	4,787	3
0– 0– 0	15.75	13.02	82.66	19.5	174.8	3,409	6

TABLE 12—Upper Ten Field, P.O.J. 213 2nd. year stubble.

Pounds of Plant Food Constituent Per Acre N P K	Station Mill Analyses			Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre	Rank
	Brix	Sucrose	Purity				
40–20–20	14.48	11.46	79.13	18.2	150.0	2,730	3
40–20– 0	14.62	11.62	79.47	18.5	152.5	2,821	1
40– 0–20	14.81	12.12	81.83	17.0	161.8	2,750	2
0–20–20	15.08	12.34	81.83	13.9	164.6	2,288	5
40– 0– 0	14.78	12.13	82.07	16.6	162.1	2,691	4
0– 0– 0	15.19	12.36	81.36	11.8	164.4	1,939	6

BUBENZER FIELD: Fertilizer applied April 15th, 1930. Sugar cane harvested December 9th and 10th, 1930.

ELLENDALE FIELD: Fertilizer applied April 7th, 1930. Sugar cane harvested December 3rd, 1930.

UPPER TEN FIELD: Fertilizer applied April 8th, 1930. Sugar cane harvested November 12th, 1930.

BUBENZER TEST FIELD

Bunkie, La.

The Bubenzer Test Field, Table 10, is situated about 2 miles north of Bunkie, La. It is on Yahola very fine sandy loam, an extensive type of that section (Page 8). The table differs from those in former pages in that the fertilizer formulas are in terms of pounds of plant food per acre.

The straight nitrogen application at the rate of 40 pounds per acre gave the best tonnage, whereas the mixture of 20 pounds of phosphoric acid and 20 pounds of potash made the largest gain in sugar per acre. While very little dependence can be placed in the 1929 results, due to freezes, it is interesting to note that the 1930 yields, which represent first year stubble, show a small increase in tonnages for all plots except check and the nitrogen free mixture. The rank of the 1930 results in terms of sugar per acre is given in the extreme right hand column.

ELLENDALE TEST FIELD

Houma, La.

In Table 11 the results of the Ellendale Field are given. This experiment is on Yazoo very fine sandy loam (Page 7) the most extensively developed soil type of the District. As in Table 6 the fertilizer formulas are stated in terms of pounds of plant food per acre.

The greatest return in tonnage and sugar per acre was from the complete fertilizer plot whereas 40 pounds of nitrogen and 20 pounds of potash gave the second highest yield. The return from the straight nitrogen plot is only 55 pounds less than the complete fertilizer mixture. In every case nitrogen shows a substantial increase over check. Comparing 1930 results with 1929 the check shows a 2.8 tons loss, the 40-20-20 a 4.1 tons increase, the 40-20-0 a 4.1 increase, 40-0-20 a 3.9 increase, the 0-20-20 an .8 ton loss and the 40-0-0 a 2.8 increase.

UPPER TEN TEST FIELD

Raceland, La.

The Upper Ten Field located near Raceland, La., is on Yazoo very fine sandy loam (Page 7). The second year stubble did not winter well and the stand was irregular and poor.

The fertilizer mixtures, Table 12, which are in terms of pounds of plant food per acre show the following results: The complete fertilizer mixture, nitrogen and phosphoric acid and the nitrogen and potash gave the highest yields though there is little to choose between the three. Straight nitrogen at the rate of 40 pounds per acre ranks forth and shows only 130 pounds less than the highest. These results, however, due to poor stand cannot be depended upon, and a comparison with the 1929 yield would hardly be justified.

RATE AND SOURCE OF NITROGEN

Since nitrogen is of tremendous importance in the successful production of sugar cane it was considered necessary to determine the most economic rates of application and study the effects of the more common nitrogen carriers.

In the spring of 1930 an extensive experiment was designed and laid out on Mandalay Plantation, near Houma, Louisiana. Four rates, 20, 40, 60 and 80 pounds of nitrogen per acre, of the more common carriers Sulphate of Ammonia, Cyanamid, Calcium Nitrate, Calurea and Nitrate of Soda were replicated twice. The experiment was placed on a very uniform body of Yazoo very fine sandy loam where the stand of sugar cane was extremely even so as to eliminate, as far as possible, all chances of error.

In Table 13 the 1930 results are given. The tons of sugar cane per acre show, in nearly every case, a steady increase up to applications of 80 pounds of nitrogen per acre whereas the pounds of sugar per acre indicate no economic return beyond the 40 pound rate. It would appear, therefore, that applications of over 40 pounds of nitrogen per acre are of little economic value when this plant food element is used alone. It also seems that there is little difference in the action of the carriers. But the results represent only one year's work and the experiment will be continued in order that more data may be collected.

TABLE 13—Effect of various rates and source of nitrogen on 1st. year stubble of P.O.J. 213 cane.

Source	Pounds of Nitrogen Per Acre	Station Mill Analyses			Tons Cane Per Acre	Pounds Sugar Per Ton	Pounds Sugar Per Acre
		Brix	Sucrose	Purity			
Amon. Sulphate	20	15.61	13.11	83.98	27.8	177.6	4,937
	40	15.53	12.86	82.81	29.8	172.9	5,152
	60	14.90	11.37	76.31	28.8	145.5	4,190
	80	14.96	11.40	76.20	34.4	145.9	5,019
Cyanamid	20	16.13	13.88	86.05	24.5	190.6	4,670
	40	15.86	13.60	85.75	30.1	186.3	5,608
	60	15.12	12.35	81.68	27.6	164.7	4,546
	80	14.42	10.89	75.52	31.8	138.5	4,404
Cal. Nitrate	20	16.27	14.07	86.48	25.4	193.6	4,917
	40	15.74	13.16	83.61	30.9	177.8	5,494
	60	16.11	13.71	85.10	29.3	187.1	5,482
	80	14.66	11.41	77.83	32.8	147.9	4,851
Calurea	20	15.83	13.25	83.70	27.0	179.2	4,838
	40	15.82	13.42	84.83	27.3	182.7	4,988
	60	15.38	12.60	81.92	28.4	168.3	4,780
	80	14.77	11.62	78.67	33.3	152.3	5,072
Sodium Nitrate	20	15.97	13.70	85.78	25.4	187.7	4,768
	40	16.06	13.69	85.24	28.6	183.7	5,254
	60	15.52	12.68	81.70	29.5	169.3	4,994
	80	15.91	13.29	83.53	29.4	179.5	5,277
Average of 16 Check Plots..	–0–	15.69	13.21	84.20	20.8	179.1	3,725

Fertilizer applied April 10th and 11th, 1930. Sugar cane harvested November 24th and 25th, 1930.

CORRELATION OF SOIL TYPE, pH, TONNAGE AND SUGAR CONTENT

During the 1929 season 868 samples were collected from the principal soil types of the Sugar Cane District of Louisiana for pH determinations.[1] Except for the acid types Lintonia silt loam

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(1) pH determinations were made at the Government Station, Houma, La. by Nelson McKaig, Jr.

and Olivier silt loam found in the terrace section at Lafayette, there was not a very close correlation between soil type and pH.[2] The general trend was interesting, however, and since the number of samples was not sufficient to justify any definite conclusions it was deemed advisable to continue the work along broader lines.

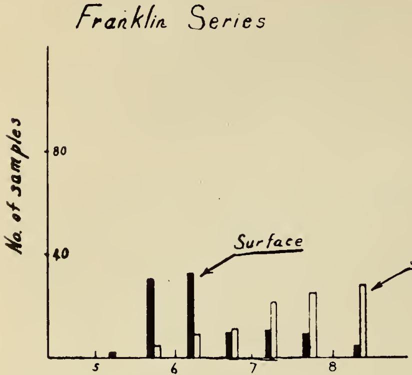

Fig 1 - 100 Samples
Sterling Plantation

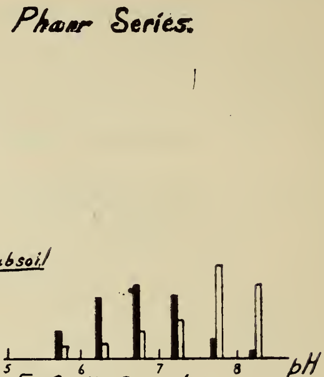

Fig. 2 - 100 Samples
Sterling Plantation.

The 1930 experiments followed a more definite plan and the various tests were designed to study not only pH reactions of certain given areas, but the effect of acidity and soil type on tonnage and sugar content.

The plan of the work consisted of an intensive study of small areas of the dominant soil types of each section. The results are given in Tables 14 and 15, and shown graphically in Figures 1 to 10. In each case these areas were selected for uniformity of

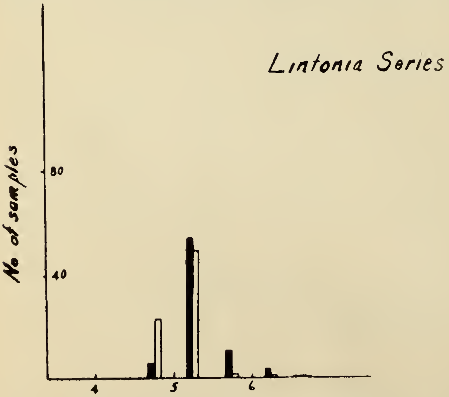

Fig 3 - 75 Samples
Roy Plantation

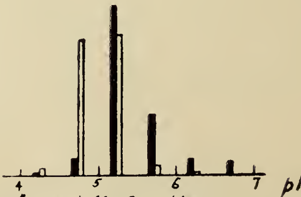

Fig. 4 - 110 Samples
Random over Cane Belt.

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(2) pH made by Quinhydrone method using M/20 potassium phthalate-quinhydrone as a reference half cell having a value of pH 3.98.

soil type and sugar cane stand. The same variety of cane was used. Surface samples were taken from 0 to 8 inches and the subsoil from 10 to 24 inches.

The results of the one year's work, as set forth in Table 15, seem to indicate that no dependence can be placed in the effect of pH on tonnage and sugar content. At both Cinclare and Raceland the light textured types gave the highest yields as was expected, but at Franklin, which is within the limits of the Missis-

Yazoo Series

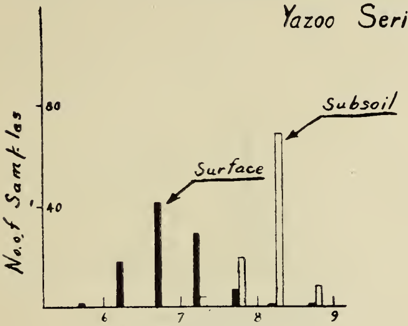

Fig. 5 - 100 Samples
Cinclare Plantation

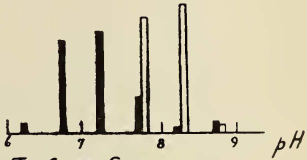

Fig. 6 - 100 Samples
Mary Plantation.

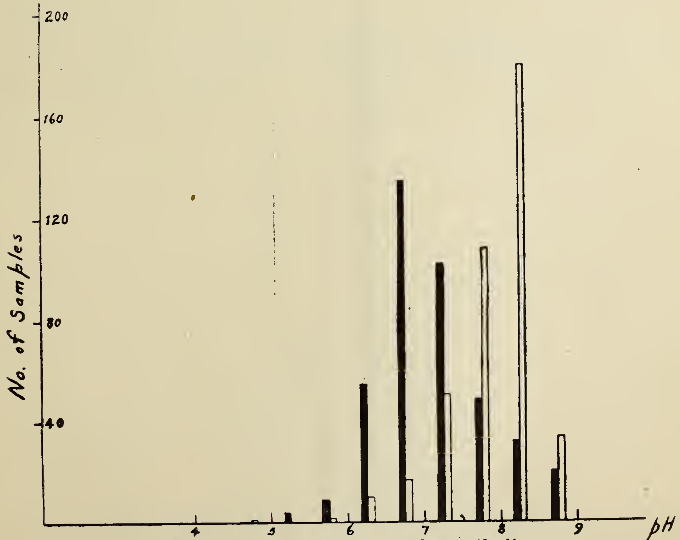

Fig. 7 - 406 Samples from all parts of Cane Belt.

sippi-Red River area, the heavier soil shows the high return. Again at Lafayette an acid soil shows the highest yield. Apparently acidity is not the whole story.

In Table 14, which gives the location, number and pH range of the different samples, there is a very definite trend shown when

Sharkey Series

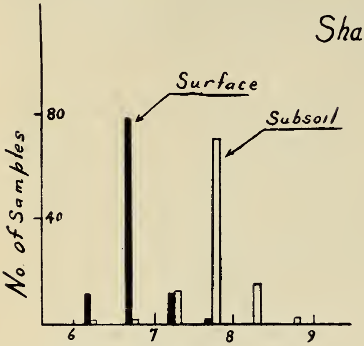

Fig. 8 - 100 Samples
Cinclare Plantation

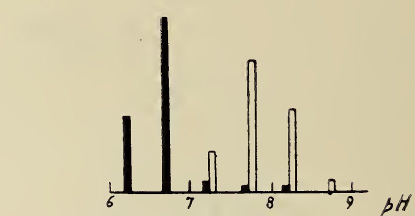

Fig. 9 - 100 Samples
Mary Plantation

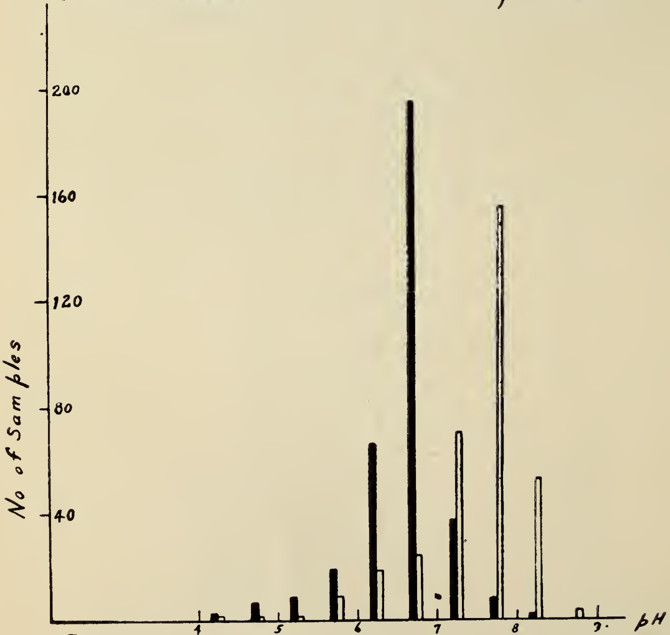

Fig. 10 - 340 Samples from all parts of Cane Belt

the same soil types collected from widely separated points in the same major soil area are compared. For instance, the Sharkey silty clay samples collected from Mary Plantation, Raceland, and Cinclare Plantation, Cinclare, points approximately 100 miles apart, have much the same pH range. Even when 240 random samples from all parts of the section are included, no change is indicated other than a few more extreme points. This is shown more clearly in Figures 8 to 10.

The Yazoo very fine sandy loam, silt loam and loam samples from Mary and Cinclare show much the same trend. The curves are uniform, Figures 5 to 7, but differ from the Sharkey in that the peak is not so sharply defined.

The soils of the Franklin series, which are developed in the Mississippi-Red River Area, have many of the same profile characteristics as the Yazoo. It is interesting to note, however, that the pH range is acid instead of alkaline. In Figure 1 it will be observed that 64 surface samples out of the hundred fall within pH 5.50 and 6.50 range. The surface curve flattens out gradually on the alkaline side with a number of overlaps. The subsoils are alkaline without any sharp trends.

The 100 Pharr silt loam and silty clay loam samples do not show any marked correlation.

The Lintonia silt loam gives a rather striking correlation which is more outstanding when the samples are from restricted areas. Figs. 3 and 4.

TABLE 14

Soil Type	Location	Horizon	No. Samples	Number of Samples Between pH Intervals										
				4.00	4.50	5.00	5.50	6.00	6.50	7.00	7.50	8.00	8.50	9.00
Sharkey Silty Clay	Cinclare Pltn. Cinclare, La.	Surface	100	....	....	....	....	11	77	11	1	....	....	....
		Subsoil	100	....	....	....	....	1	1	12	69	15	2	....
Sharkey Silty Clay	Mary Plantation Raceland, La.	Surface	100	....	....	....	....	28	66	4	1	1	....	....
		Subsoil	100	....	....	....	....	....	....	15	50	31	4	....
Sharkey Series	Random Samples	Surface	340	2	5	8	19	66	195	37	7	1	....	....
		Subsoil	340	1	1	1	8	18	24	71	156	53	6	....
Yazoo v. f. s. Loam and Silt Loam	Cinclare Pltn. Cinclare, La.	Surface	100	....	....	....	1	18	42	30	7	1	1	....
		Subsoil	100	....	....	....	....	....	....	4	20	68	8	....
Yazoo v. f. s. Loam and Silt Loam	Mary Plantation Raceland, La.	Surface	100	....	....	....	....	4	36	40	14	2	4	....
		Subsoil	100	....	....	....	....	....	....	....	46	51	3	....
Yazoo v. f. s. Loam and Silt Loam	Random Samples	Surface	406	....	....	4	9	55	135	103	48	32	20	....
		Subsoil	406	....	1	....	2	11	17	51	108	182	34	....
Franklin v. f. s. l. and Silt Loam	Sterling Pltn. Franklin, La.	Surface	100	....	....	2	31	33	10	11	9	4	....	....
		Subsoil	100	....	....	....	5	9	12	22	25	27	....	....
Pharr s. l. and Silty Clay Loam	Sterling Pltn. Franklin, La.	Surface	100	....	....	....	12	24	29	25	7	3	....	....
		Subsoil	100	....	....	....	5	6	10	15	36	28	....	....
Lintonia Silt Loam	Roy Plantation Lafayette, La.	Surface	75	....	6	54	11	3	1	....	....	....	....	....
		Subsoil	75	....	23	49	2	1	....	....	....	....	....	....
Lintonia Silt Loam	Random Samples	Surface	110	1	7	66	23	7	6	....	....	....	....	....
		Subsoil	110	3	50	53	3	1	....	....	....	....	....	....

TABLE 15

Soil Type	Location	Average pH of Surface Soil	NORMAL JUICE Brix	Suc.	Pur.	Tons Cane Per Acre	Lbs. Sugar Per Acre
Sharkey Silty Clay	Cinclare Plantation Cinclare, La.	6.76	14.23	10.65	74.84	15.3	2,058
Yazoo v. f. s. Loam	Cinclare Plantation Cinclare, La.	6.90	13.76	9.01	65.48	24.1	2,482
Sharkey Silty Clay	Mary Plantation Raceland, La.	6.65	13.31	9.41	70.68	19.4	2,159
Yazoo v. f. s. Loam	Mary Plantation Raceland, La.	7.18	13.98	10.59	75.68	25.3	3,416
Pharr Silty Clay Loam	Sterling Plantation Franklin, La.	6.74	16.78	13.38	79.75	20.2	3,563
Franklin v. f. s. Loam	Sterling Plantation Franklin, La.	6.61	16.89	13.70	81.11	17.8	3,241
Lintonia Silt Loam	Roy Plantation	5.34	15.78	12.43	78.77	26.2	4,255

CARRY OVER EFFECT OF FERTILIZER FROM ROW TO ROW

Field observations indicate that where plots treated with different fertilizer mixtures are laid out without intervening buffers the outside rows of each plot show the effect of the adjoining mixture. But there are no data available to prove the extent of this influence and the number of buffer rows necessary.

Since such information is important an experiment was designed and laid out as shown in Figure 11. Each plot is 20 feet long and 8 rows wide. Two plots received 60 pounds of nitrogen per acre and two 120 pounds. In each case the fertilized plots are separated by checks. At harvest the sugar cane on each row was cut and weighed separately.

In Table 16 the average of the rows 1 and 8, 2 and 7, 3 and 6, and 4 and 5 of the checks and fertilized plots are shown. Rows

1 and 8 of the checks adjoin 1 and 8 of the fertilized plots whereas 4 and 5 are the center rows of each plot. In other words rows 4 and 5 should represent the true condition of each plot whether check or fertilized.

An analysis of the results in Table 16 shows that rows 2 and 7, 3 and 6, and 4 and 5 for check 1 and 2 gave practically the same weight whereas the outside rows which are next to the plots that received 60 pounds of nitrogen per acre are distinctly heavier. The same is true of the check plots 3 and 4. In the case of the outside rows of the 60 pound plots the decrease in weight is not as marked as might be expected. This also holds true where 120 pounds of nitrogen per acre was applied. These results are shown more clearly in the graphs, Figures 12, 13 and 14.

The results of this experiment indicate that only the outside rows of the plots are effected, the fertilized rows negatively and the checks positively. It should be borne in mind that these results are on one year's work.

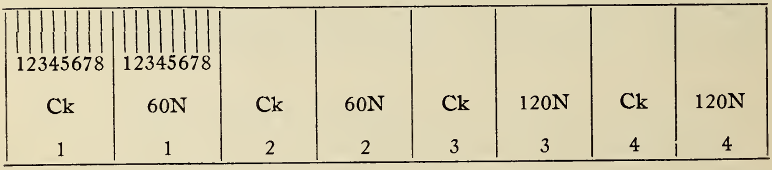

Fig. 11—Plot arrangement of carry over effect experiment.

TABLE 16—Showing weight of cane per row using pairs of the opposite rows in each plot.

Plots	ROWS			
	1 and 8	2 and 7	3 and 6	4 and 5
Checks 1 and 2	132	129	122	128
60 N—1 and 2	216	215	206	220
Checks 3 and 4	141	118	124	110
120 N—3 and 4	192	206	190	200
Average of Checks	137	123	123	119
Average of Fertilized plots	204	211	198	210

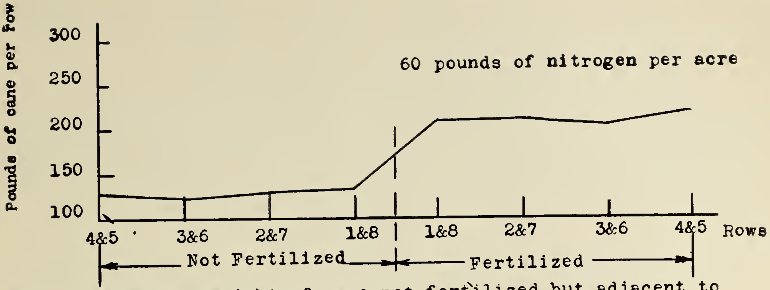

Fig. 12 Effect on weight of cane not fertilized but adjacent to fertilized plots.

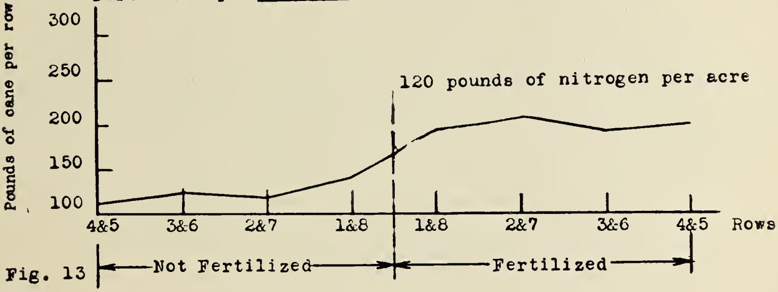

Fig. 13

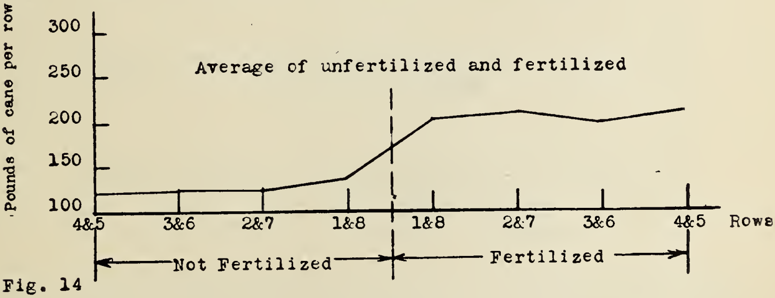

Fig. 14

APPENDIX

In all the triangle experiments the formulas are in terms of per cent of the principal plant food elements nitrogen, phosphoric acid and potash. They may be converted into pounds of the plant food elements as follows:

Let us assume that the mixture 12 per cent nitrogen, 4 per cent phosphoric acid, 4 per cent potash is to be applied at the rate of 60 pounds of plant food per acre.

The mixture stated in terms of plant food per acre would be 36 pounds of nitrogen (N), 12 pounds of phosphoric acid (P_2O_5)

and 12 pounds of potash (K_2O) arrived at in the following manner:

$$\frac{\text{per cent of each of the plant food elements}}{\text{sum of percentages of the plant food elements}} \times \begin{array}{l}\text{total plant food}\\ \text{wanted per acre}\end{array}$$

or

$$\frac{12}{20} \times 60 = 36 \text{ N}, \quad \frac{4}{20} \times 60 = 12 \text{ } P_2O_5 \text{ and } \frac{4}{20} \times 60 = 12 \text{ } K_2O$$

Assuming the nitrogen source to carry 16 per cent N, the superphosphate 16 per cent P_2O_5 and the muriate of potash 50 per cent K_2O the pounds of the different materials can be calculated as follows:

$$\begin{array}{lrl}
\frac{36}{16} \times 100 = & 225 & \text{pounds of any 16 per cent nitrogen fertilizer.} \\
\frac{12}{16} \times 100 = & 75 & \text{pounds of any 16 per cent superphosphate fertilizer.} \\
\frac{12}{50} \times 100 = & \underline{24} & \text{pounds of any 50 per cent potash fertilizer.} \\
 & 324 &
\end{array}$$

Therefore a 12% N, 4% P_2O_5, 4% K_2O mixture requires 324 pounds of a mixed fertilizer with the above plant food guarantees, to supply 60 pounds of total plant food per acre.

Literature Cited:

(a) The Triangle System of Fertilizer Experiments is explained in an article by Oswald Schreiner and J. J. Skinner in Journal American Society of Agronomy, Vol. 10, pages 225-246, (1922).

(d) U. S. D. A. Circular No. 418, R. D. Rands and S. F. Sherwood.

Acknowledgments:

The success of the experiments reported in this Bulletin was due, in large measure, to the splendid co-operation of:

L. A. Hurst, Division of Soil Investigations, Bureau of Chemistry and Soils.

W. G. Taggart, Ass't Director, L. S. U. Experiment Station.
Est. Harry L. Laws, Cinclare, La.
Percy Lemann, Donaldsonville, La.
Godchaux Sugars, Inc., Raceland, La.
Est. H. C. Minor, Houma, La.
Sterling Sugars, Inc., Franklin, La.
J. A. Roy, Lafayette, La.
H. K. Bubenzer, Bunkie, La.
Andrew McCollum, Houma, La.
Nelson McKaig, Bureau of Chemistry and Soils, Houma, La.
George Arceneaux, Bureau of Plant Industry, Houma, La.
U. S. Weather Bureau, New Orleans, La.

JULY, 1931 LOUISIANA BULLETIN 223

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STUDIES ON SUGAR CANE ROOTS

By

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STUDIES ON SUGAR CANE ROOTS

T. C. RYKER and C. W. EDGERTON

INTRODUCTION

A THOROUGH knowledge of plant roots and their activities is of great importance to any one working with plants. Roots absorb the water and mineral salts which are necessary if growth activities are to continue. Roots also support the plant and act as organs of storage, storing up materials which can later be used by the plant. Furthermore, the activities of roots are influenced to a very great extent by the soil conditions around them. Temperature, soil moisture, the physical and chemical conditions of the soil, and many other factors may not only check or stimulate root growth but may decrease or increase in one way or another the efficiency of the roots. A knowledge of how the roots grow, develop and carry on the essential functions should help the plant grower to select those cultural practices which will tend to make the plants more efficient. Plant growth and crop yields are governed to a large extent by the efficiency of the roots.

The reduction in yield of sugar cane resulting from a failure of the plants to make a satisfactory growth has been an important problem in the sugar belt of Louisiana for many years. Growth failure may occur as a result of poor germination of the buds on the planted stalks and stubbles or from the inability of the plants to respond to favorable growing conditions. In practically all cases, this poor growth is due primarily to a failure of the roots of the plants to function as they should. They are apparently unable to furnish a sufficient amount of water and mineral salts to meet the requirements of the growing plant.

At the request of the American Sugar Cane League, a special study is being made of the structure, development and behavior of sugar cane roots. In this bulletin, the information which has been obtained during a period of two years and which may have a bearing on the field operations of the growers, is recorded.

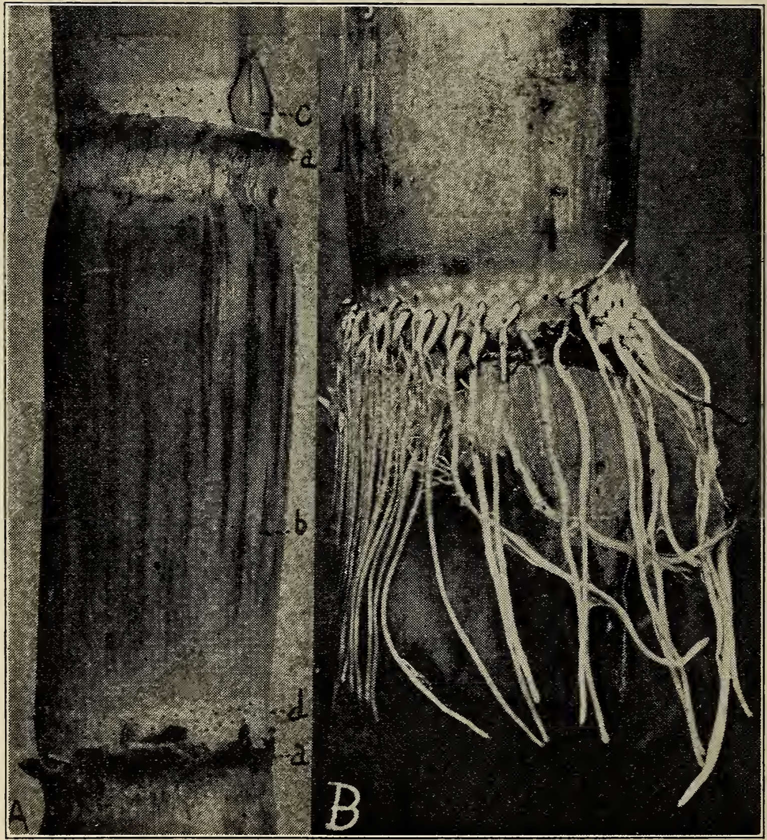

FIG. 1. SUGAR CANE STALKS
A. Stalk in growing condition. (a) Node, (b) Internode, (c) Bud or Eye, (d) Root band.
B. Root development from root band area on sugar cane stalk.

SUGAR CANE STALK

A stalk of sugar cane (Fig. 1A) is made up of joints, the number and size of these depending largely on the variety and the environment under which the plant is grown. The portions of the stalk which are of particular interest are (a) node, (b) internode, (c) bud or eye, (d) root band.

The node is the section of tough, fibrous tissue which separates the joints.

The internode is the portion between two nodes.

The bud or eye is situated just above the node. The bud is capable under the right moisture and temperature conditions of producing a new shoot. The buds are arranged alternately on the opposite sides of the stalk.

The root band is a small section of the stalk just above the node. This is generally somewhat different in color and on it occur a great many small dots usually in rows. These dots are thin places in the rind tissue and are directly over the root primordia. Under the right moisture conditions, a root develops from each of these (Fig. 1B). All the roots which are produced by the cane plant come from the root band area.

The portion of the stalk underground, which is structurally no different from the portion above ground, is often called the rootstalk. In Louisiana, these portions after harvest are called stubbles. During the growing season, the buds on the rootstalks develop into suckers and the roots which are necessary for the growth of the plants develop from the root bands on the internodes.

SUGAR CANE ROOT

The roots of the sugar cane plant are fibrous in nature. The main roots which develop from the root band on the growing stalk are usually called the primary roots. As the roots grow, they branch repeatedly and finally permeate the soil in every direction. The branches are usually called secondary and tertiary roots. A root when first formed is nearly white in color and is covered with many small root hairs. As the root extends further out in the soil, the older portion near the stalk becomes dark in color and the root hairs disappear. Absorption of water and mineral salts takes place to a very large extent in the white portion near

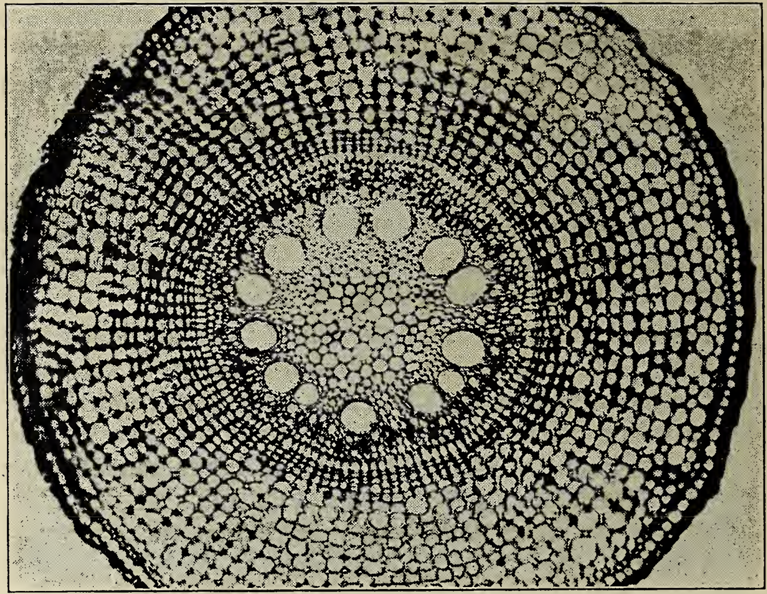

Fig. 2. Cross section of young sugar cane root, showing the stele surrounded by the cortex.

the tip. A cross section of the white portion (Fig. 2) shows that there are two main parts of the root, the stele and the cortex. The stele located in the center of the root is more or less circular in cross section and contains a number of large openings which are the open ducts through which the soil solution absorbed by the roots is carried back to the stalk. The cortex is the rather thick area surrounding the stele. The root hairs, shown in figure 3A, extend outward from the outer layer of cells, the epidermis. The soil solution is taken up by the root hairs and epidermis and is then carried through the cortex cells to the ducts in the central stele.

If a section is made through the older dark colored portion of the root, it will be seen that the cortex cells are dead and are left in the form of shreds connecting

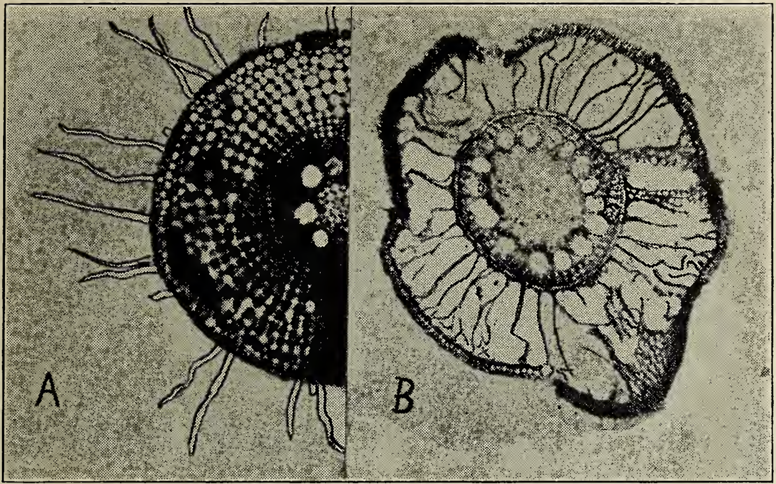

FIG. 3. CROSS SECTIONS OF SUGAR CANE ROOTS
A. Young root showing root hairs.
B. Old root showing the breaking down of the cortex.

the epidermis to the stele (Fig. 3B). The cortex has become merely a spongy dead layer surrounding the living, functioning stele. It seems that as soon as the young portion of the root grows out, the old portion ceases to function as an absorbing organ and the cortex cells, being of no further use, die.

It is evident then that a well-developed and rapidly growing root system is necessary for a maximum growth of the sugar cane plant. It is evident also that any serious injury to the growing root tips or any unfavorable environmental factor such as an unsatisfactory temperature or soil condition which prevents a proper root development, will check the growth of the plants. Injuries may come from root rotting organisms such as Pythium which kill the root tips, or they may come from cultivation practices that destroy the terminal portions of the roots. The actual damage resulting from the destruction of portions of the roots, of course, will vary to a considerable extent.

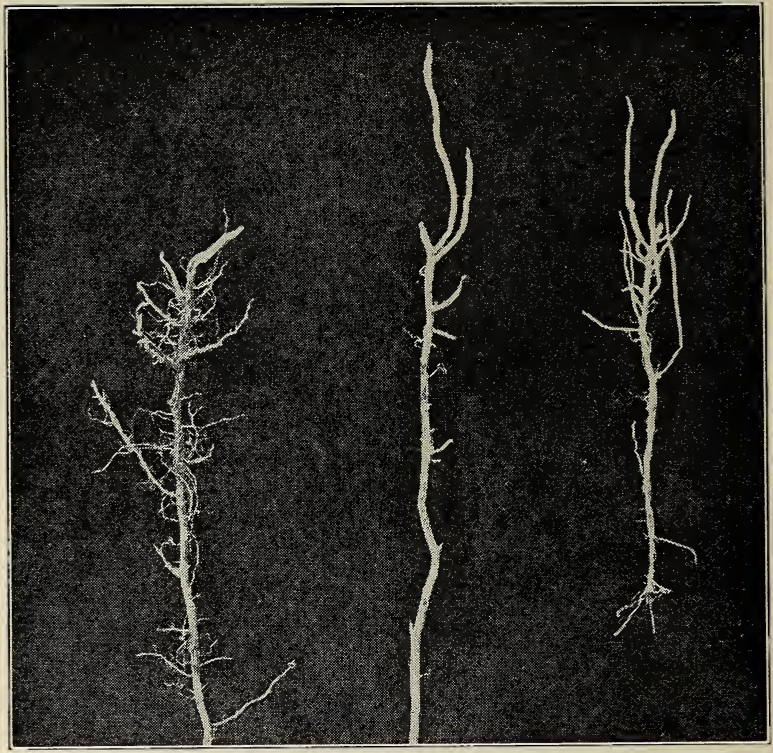

Fig. 4. Young roots of sugar cane, showing the formation of branches after the destruction of the growing tips.

If the soil is wet and conditions are favorable for the rapid development of new roots, no material checking of growth may be noticed (Fig. 4), but if the soil is dry or conditions are unfavorable for the development of new roots, the checking of growth may be very marked.

IMPORTANCE OF SEEDPIECE ROOTS

Sugar cane is propagated by planting portions of the stalks. In Louisiana, the whole stalk is usually planted but in the tropics, the stalks are ordinarily cut into seedpieces. When placed in the soil, the buds or eyes swell and finally produce shoots.

When the seedpieces are planted, roots develop on the seedpieces from the root bands at the nodes. The roots develop independently of the buds though some of the latter usually start at about the same time. Many of the buds, however, do not germinate until later. Usually a considerable number of roots develop on each joint of the seedpiece, though all of the root primordia do not develop at once. A considerable number are held in reserve and only produce roots if something happens to those which are first produced.

These seedpiece roots grow out into the soil and if conditions are favorable may reach a length of two feet. The continued development of these roots depends to some extent on the developing buds. If the bud germinates and grows, the seedpiece roots will continue to grow for some time. If the bud is killed or fails to grow, the growth of the roots is checked and usually they deteriorate prematurely. These seedpiece roots seem to be necessary for a normal growth of the shoots, as they support the young plants until the latter have developed root systems of their own.

The young plant does not put out roots of its own (primary roots) until new joints develop at the base. If the shoot is growing rapidly and the seedpiece roots are abundant and well-developed, the young stalk may reach a height of six to ten inches and sometimes even more before primary roots develop. If, however, the seedpiece roots are deficient or the plant is growing poorly, primary roots will be developed earlier.

That the young shoot depends on the seedpiece roots for a considerable period or until it has time to produce a root system of its own was mentioned by Dr. Stubbs as early as 1897. Recent tests on a much larger scale confirm these earlier observations.

Plants were grown from seedpieces in pots in the greenhouse in sets of three different treatments. In the first set, the roots were allowed to develop in a normal manner on the seedpieces. In the second, the seedpiece roots were removed at frequent intervals. In the third, the root primordia were cut out of the seedpieces with a knife before planting. In all of the sets, shoot development was about the same until the plants were from five to six inches tall,

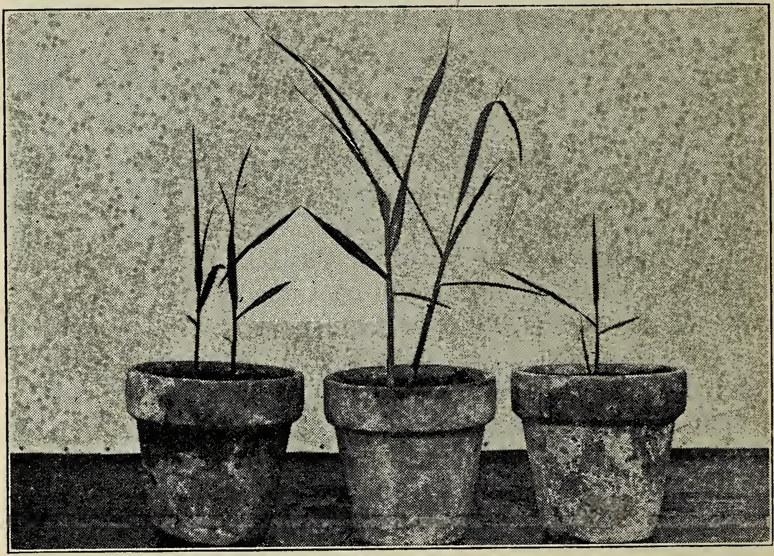

Fig. 5. Sugar cane growth after injury to the seedpiece roots. Plants on left, roots removed at weekly intervals from seedpieces. Plants on right, root primordia removed from seedpieces with knife. Plants in center, seedpiece roots permitted to develop normally.

but after that differences began to show (Fig. 5). Plants from the seedpieces with normal roots developed much more rapidly than the others. The plants in the other sets grew very slowly. The plants growing from the injured seedpieces were more severely affected than those from seedpieces that had the roots removed. This, however, was to be expected as the injured seedpieces had no supporting roots while the others did have short ones that developed and grew before they were removed. Shoots from seedpieces with a deficient root system showed the symptoms which ordinarily occur when plants are not obtaining sufficient water and plant food. It would seem that the young plant does not use to any great extent the substances stored up in the seedpiece, and certainly does not obtain much of its water supply from that source.

Since the young shoot at first depends to a very large extent upon the seedpiece roots, it is evident that a serious destruction of these by root-rotting organisms must tend to materially check the growth of cane in the early spring.

Inoculation experiments with the root rotting fungus, Pythium, have shown that this organism can destroy the seedpiece roots very rapidly. The conditions most favorable for this decay are those brought about by low tem-

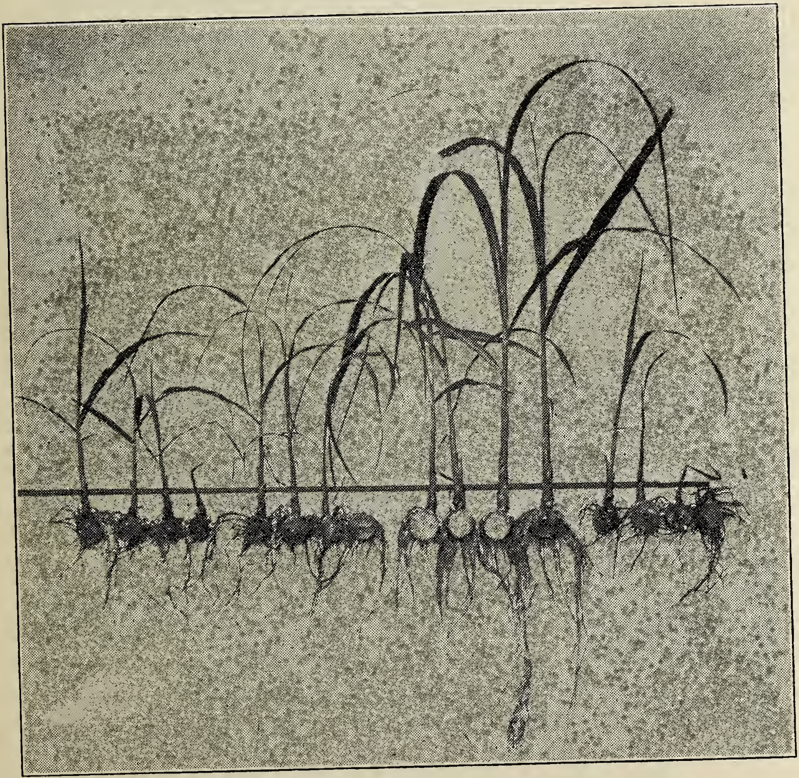

Fig. 6. Sugar cane growth following the destruction of seedpiece roots by decay organisms. All plants except those in right center had seedpiece roots killed by the fungus, Pythium.

peratures combined with a high moisture content of the soil. In figure 6 are shown plants which had been grown in Pythium-infested and Pythium-free soils. It is readily seen that the plants from the Pythium-infested soil were very similar to those grown from seedpieces from which the roots had been removed.

This helps to explain the fact that poor growth and low yields usually occur in seasons following cold wet winters when conditions are very favorable for the decay of the roots. For a maximum early growth, conditions favorable for the development of seedpiece roots must be maintained.

ROOTS ON STUBBLE PIECES

During the growing season, practically all of the root primordia on that part of the stalk which is underground, produce roots. There is a band of roots around each underground node. Consequently, when the stalk is cut at harvest time in the fall, the stubble piece which is left in the ground and which usually consists of from five to ten short joints has a well-developed root system. It is from these stubble pieces that the stubble or ratoon crop develops the following season.

Fundamentally, the production of a shoot from a stubble piece is in no way different from the production of a shoot from a planted stalk. The differences which sometimes occur in the behavior of shoots from planted stalks and from stubble pieces must necessarily be due to the root condition. On the planted stalks, new roots are produced at every node, while on the stubble, the roots are already present. Very seldom are new roots produced from the stubble pieces during the winter and spring. By digging up stubble pieces and placing them in moist chambers where conditions are the most favorable for root development, it has been possible to occasionally force a new root to develop but under field conditions, this only occasionally occurs. An examination of a large number of stubble pieces in June, 1931, resulted in the finding of a few new roots on Co. 281 but none on C.P. 807 or P.O.J. 36 M.

As it is known that the young shoot absorbs its water supply from the roots, it is evident that the shoot on the stubble piece must depend on the old roots of the previous season. The production of shoots, then, from stubble and the vitality of these shoots will depend to a considerable extent on the vitality of the stubble roots. It is evident that the failures which have often followed attempts to rapidly propagate cane by transplanting stubble pieces is at least partially due to the deficiency of roots on these seedpieces. If conditions of growth are unfavorable, shoot development and growth are materially retarded.

To obtain some direct information on the importance of the old roots on the stubbles, experiments have been carried on over a period of two years.

The first test was started in the fall of 1929. Plant cane of the variety P. O. J. 234 growing in mixed soil was cut early in the fall. With a large knife, the stubble roots were then severed to a depth of about ten inches around each stool. This did not remove all the roots but it removed all of those extending out in the surface layers of the soil which was probably between 80 and 90% of the entire root system. Twenty-four stools were treated in this way, while sixty others were left for checks. In the spring of 1930, only two shoots developed on the treated stools while the sixty untreated stools developed twenty-five shoots.

In the fall of 1930, this experiment was run on a considerably larger scale. Early and late cut cane of different varieties were used. As in the previous year, the roots were cut with a large knife close to the stools to the depth of eight to ten inches. The results obtained from the 1930-31 tests are given in table 1.

TABLE 1

SHOOT DEVELOPMENT FOLLOWING THE CUTTING OF OLD STUBBLE ROOTS, 1931

Variety	Cane Cut	Roots Cut	Treatment	May 5		June 8	
				No. of Stools	No. of Shoots	No. of Stools	No. of Shoots
P. O. J. 36 M	Early October	Nov. 1	Roots cut . .	46	59	46	91
			Check	46	70	46	129
P. O. J. 213	Early October	Nov. 1	Roots cut . .	50	44	47	98
			Check	50	41	47	99
Co. 281	October 20	Nov. 1	Roots cut . .	14	58	14	105
			Check	14	77	14	119
P. O. J. 36 M	December	Feb. 16	Roots cut . .	55	170	51	329
			Check	55	216	51	386
P. O. J. 213	December	Feb. 16	Roots cut . .	30	71	30	140
			Check	30	93	30	200
Co. 281	October	Feb. 16	Roots cut . .	14	71	14	104
			Check	14	80	14	126

As in the previous year, the cutting of the roots even to a depth of eight to ten inches materially reduced the germination of the stubble pieces. It is also important to note that the cutting of the roots as late as February 16 affected the recovery of the cane as severely as cutting in early November.

Examinations made in the field in the spring of 1931 showed that many old stubble roots were still alive in June, though many had begun to deteriorate by that time.

EFFECT OF SOIL CONDITION ON ROOT DEVELOPMENT

While it has been indicated that the pruning of the root system by cultivation practices may be harmful to cane plants, this does not mean that cultivation is not necessary. It does show, however, that cultivation practices that will leave the soil in the most desired condition and at the same time will destroy as few roots as possible are those which will give the maximum yields of cane.

Besides the necessary destruction of weeds and grass, cultivation improves the soil in at least three important ways. It loosens the soil so that the plant roots can penetrate it more readily, it allows the entrance of the oxygen which is necessary for the proper growth of the roots, and it conserves the supply of moisture. Some of the cane soils, especially the heavy black soils, become very compact and the lack of oxygen in such soils must cause a partial asphyxiation of the roots. It is certain that the roots do not penetrate this type of soil satisfactorily. The judicious breaking apart of these compact soils by cultivation is not only beneficial but very necessary. This is brought out clearly in the photograph of a root system shown in figure 7. This stool of stubble P. O. J. 213 cane was grown in heavy black soil and the soil was dug away from the roots in October. The excessive development of roots in the off-bar furrow and

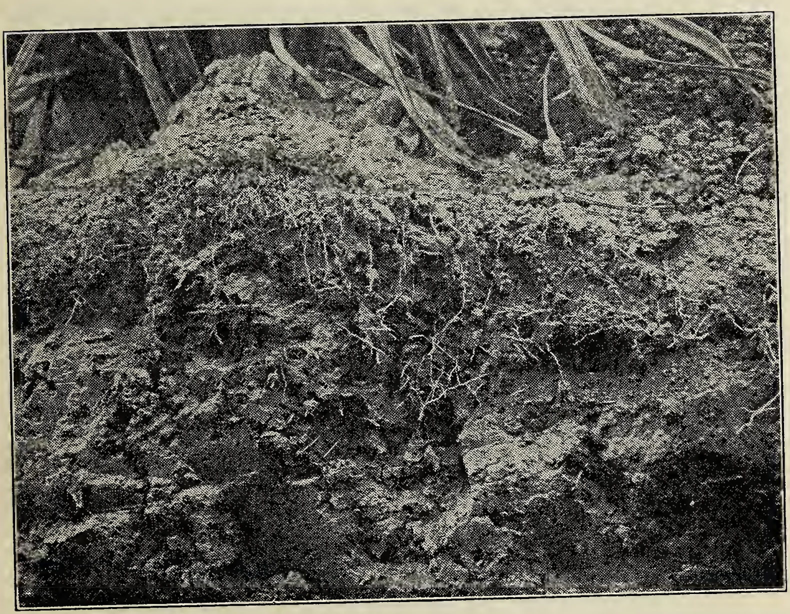

Fig. 7. Distribution of cane roots in heavy soil. The location of the off-bar furrow can be traced by the abundant root development.

the lack of roots in the compact soil under the stool is very noticeable. This demonstrates the importance of having the soil well-aerated and in such a physical condition that the roots can penetrate it. In order to put the soil in as good a condition as possible and also to destroy as few roots as possible, it would seem that off-barring and deep cultivation should follow the development of shoots on the stubble pieces and should precede the development of roots in the upper soil layers.

That cultivation does not necessarily stimulate an early growth of cane is a common observation. In figure 8 are shown two plots of cane on the Experiment Station Farm at Baton Rouge, taken in June, 1931. The cane in figure 8A was thrown out of cultivation on account of levee construction and received no cultivation, while the cane shown in figure 8B was given the best cultivation possible. At the time of taking the photograph, no material difference in the growth or vitality of the cane was noticed. Many similar observations have been made by cane growers and some will recite instances where cane has made a better yield

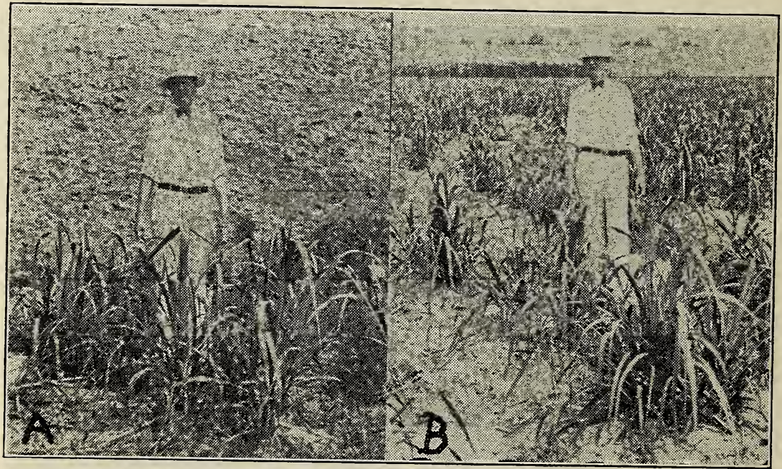

Fig. 8. Effect of cultivation on early growth of stubble in June, 1931. (a) P. O. J. 213, without cultivation, (b) P. O. J. 213, with normal cultivation.

without cultivation. Usually, however, uncultivated fields later in the year take on a yellow color and do not grow as well. This is especially true of cane on heavy, compact soils. Uncultivated soils are not generally as well aerated and they lose the soil moisture more rapidly during dry seasons. Cultivation then becomes necessary, but cultivation which destroys the feeding roots of the plants may be harmful. In dry years, such cultivation may be very harmful.

EFFECT OF TEMPERATURE ON GROWTH

It is a well-known fact that the growth of sugar cane is materially affected by temperatures. Sugar cane is a tropical plant and, as would be expected, requires a high temperature for maximum growth. The rate of growth at different temperatures and the minimum temperature at which growth will take place is information of particular interest to the Louisiana planter.

As yet, only a few preliminary experiments on the effect of temperature have been run but these have given some interesting results.

In one test, seedpieces of P. O. J. 36 cane were allowed to develop in temperature-controlled incubators at the following temperatures: 52, 61, 70, 79, 88, and 97° F. After ten days, the seedpieces were removed and the average lengths of the shoots and roots were obtained. The results of the test are given in table 2.

TABLE 2

GROWTH OF ROOTS AND SHOOTS OF P. O. J. 36 CANE DURING TEN DAYS AT DIFFERENT TEMPERATURES

Temperature	Average shoot length, inches	Average root length, inches
52°F	0	0
61°	0.25	0.25
70°	0.75	1.90
79°	3.50	2.75
88°	7.00	3.25
97°	9.50	4.00

From the preceding table, it is seen that no growth took place at 52° F., and at temperatures of 70° or under the rate of growth of shoots and roots from seedpieces was slow. The rate of growth, however, increased very rapidly as the temperature was raised to 79° F. and above.

To obtain more accurately the minimum temperature at which cane will begin growth, seedpieces of P. O. J. 213, P. O. J. 36 M, and Co. 281 were placed in cold-controlled refrigerators at temperatures of 54°, 57.5°, and 61°F and allowed to develop for thirty-seven days. Very similar results were obtained with P. O. J. 213 and P. O. J. 36 M. After twenty to thirty days, these two varieties showed a very slight growth at 54°F. Co. 281, on the other hand, showed no growth at 54°F and only a very slight growth at 57.5°F. It would seem that the minimum temperature for growth of young shoots and roots of Co. 281 is about three and a half degrees higher than for the other two varieties. It was also interesting to note that at these low temperatures many of the roots rotted severely after they had started to develop. It would seem that low temperatures maintained for sometime are very favorable for root decay. During the spring of 1931, the temperature remained near the critical point for a long period and this must have been a factor in the cane deterioration that occurred. The temperatures were just high enough to start growth but not high enough to maintain it.

DISTRIBUTION OF ROOTS IN SOIL

In order to select the most efficient methods of cultivation, drainage and fertilization, it is important to have a knowledge of the location and distribution of the cane roots in the soil. In the tropics, considerable information has been secured on root distribution and it has seemed desirable to obtain similar information in Louisiana. In general, the Louisiana results are in close agreement with those from the tropics.

Two methods have been used in obtaining information on the distribution of cane roots, (1) the root box method and (2) the soil excavation method.

In the root box method, boxes 2x2x2 feet and 3x3x3 feet were built. These were made in sections, six inches deep. On the bottom of each section was tacked strong

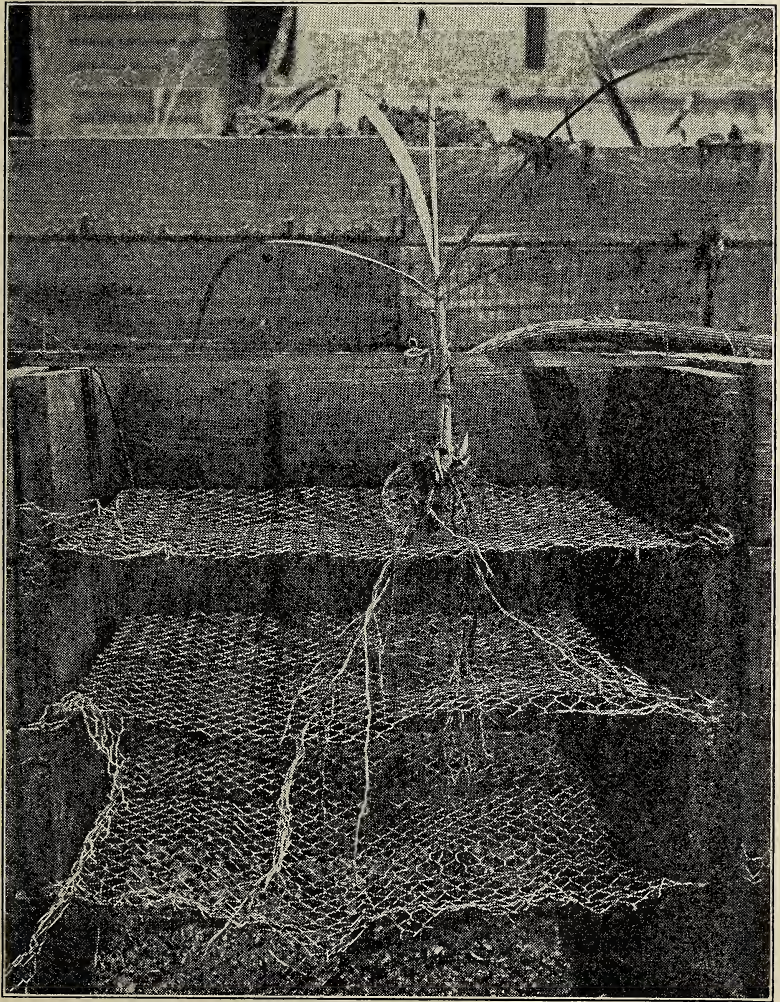

Fig. 9. Cane roots as they developed in root boxes. This shows the early downward growth of the roots.

poultry wire. These sections were nailed together as they were filled with soil. The completed box consequently had partitions of poultry wire every six inches. The lower sections of the box were filled with subsoil and the top twelve inches with top soil. Cane was planted in these boxes and permitted to grow for definite intervals. At the time the root system of the cane was to be examined, one side of the box was removed and the dirt washed away with a hose (Fig. 9). The poultry wire partitions held the roots in place and it was possible to obtain the weight of the roots in each six inch layer. During the season of 1930, boxes planted with P. O. J. 36 cane were examined twice a month. Two boxes were generally studied on each date. In table 3 the data procured from the best of the two boxes are given.

TABLE 3

DRY WEIGHT OF SHOOTS AND ROOTS AT DIFFERENT SOIL DEPTHS IN ROOT STUDY BOXES

	April 17		May 1		May 15		June 3		June 30	
	Wgt.	%	Wgt.	%	Wgt.	%	Wgt.	%	Wgt.	%
Shoot	4.6		8.3	...	9.2	...	56.2	...	228.5	...
Seedpiece Roots	0.9		0.2	...	0.2	...	...	...	...	...
Roots in different layers:										
0- 6 inches ..	0.5		1.2	41.3	0.8	29.6	4.5	28.1	17.6	21.3
7-12 inches ..	....		1.0	34.5	1.0	37.0	6.5	40.6	14.0	16.9
13-18 inches ..	....		0.5	17.2	0.5	18.5	3.5	21.9	7.0	8.4
19-24 inches ..	....		0.2	6.9	0.4	14.8	1.5	9.3	16.5	19.9
25-30 inches ..	....		....		....		....		17.0	20.5
31-36 inches ..	....		....		....		....		10.7	12.9
Total Roots	....		2.9	99.9	2.7	99.9	16.0	99.9	82.8	99.9
Ratio roots to Tops	1 to 9.2		1 to 2.8		1 to 3.4		1 to 3.5		1 to 2.7	
Shoots:										
Number	1		2		4		5		12	
Average height	7.5		4.2		4.2		8.4		7.6	

TABLE 3 (Continued)

	Aug. 1		Aug. 29		Oct. 1		Nov. 1	
	Wgt.	%	Wgt.	%	Wgt.	%	Wgt.	%
Seedpiece Roots: Shoot	503.0	...	1,498.0	...	1,412.0	...	2,746.0	...
Roots in different layers:								
0- 6 inches	59.8	50.3	177.5	60.2	317.6	77.8	420.0	74.6
7-12 inches	15.0	12.6	64.0	21.7	50.8	12.4	82.0	14.5
13-18 inches	8.5	7.1	13.1	4.4	14.0	3.4	22.0	3.9
19-24 inches	10.9	9.1	17.2	5.8	14.6	3.5	16.7	2.9
25-30 inches	17.0	14.3	16.2	5.4	5.6	1.3	9.5	1.6
31-36 inches	7.7	6.4	6.7	2.3	5.5	1.3	12.5	2.2
Total roots	118.9	99.8	294.7	99.8	408.1	99.7	562.7	99.7
Ratio Roots to Tops..........	1 to 4.2		1 to 5.0		1 to 3.4		1 to 4.8	
Shoots: Number	14		12		12		12	
Average height ..	13.1		27.0		43.5		46.1	

The first primary roots which formed on the young shoots in the boxes grew downward in the soil (Fig. 9). Later secondary and tertiary roots developed which grew out into the surface layers. The season of 1930 was very dry and as the boxes received no water except from rain the surface layers remained very dry until the rains started in the fall. This undoubtedly accounts for the smaller percentage of roots in the surface layers during the summer. During the fall, the development of roots in the surface layer was very extensive. In both the spring and fall, 65 to 90% of the roots (by weight) were in the upper twelve inches of soil.

The root development in the boxes did not differ materially from the development in the field. The development of the roots in the lower levels was somewhat more rapid and usually more extensive, but this was to be expected as the soil was looser and better aerated.

FIELD EXCAVATION STUDIES

Extensive studies have been made of the development of cane roots under field conditions. The method which has been found most satisfactory is the so-called *Excavation Method.* Well developed stools of cane were selected. The tops were cut, dried and weighed and then the soil was removed in definite layers and the roots separated from the soil by sifting and washing through a one-fourth inch mesh screen. While it is realized that many of the smaller roots went through the screen and were lost, the method seemed to give comparative results which were sufficiently accurate. In selecting the stools, only those were used which were growing under normal field conditions and were adjacent to normal stools. The area excavated was a rectangle extending to the middles and half way to the adjacent stools in the row. By having normal stools on all sides, the roots growing beyond the excavated area were counterbalanced by roots from outside plants coming into the excavated area.

The first series of excavations was made in September and October, 1929. In table 4 are given the results obtained from eleven stools.

TABLE 4

WEIGHT AND DISTRIBUTION OF ROOTS AND SHOOTS OF STOOLS OF CANE, SEPTEMBER AND OCTOBER, 1929

	D 74		D 74		Purple		Purple	
	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent
Tops and stubble (green)	6910.0	...	7337.0	...	6856.0	...	5905.0	...
Roots (dry) in different layers:								
0- 2 inches ...	8.60	6.9	20.50	12.6	22.85	14.7	12.70	10.7
3- 8 inches ...	75.25	59.0	89.45	54.9	81.50	52.4	66.65	56.2
9-14 inches ...	30.17	23.8	36.32	22.3	28.35	18.2	27.50	23.2
15-24 inches ...	9.70	7.6	10.50	6.4	14.00	9.0	7.70	6.6
25-30 inches ...	3.10	2.5	5.90	3.6	8.70	5.5	3.95	3.2
31-36 inches ...								
Total	126.82	99.8	162.67	99.8	155.40	99.8	118.50	99.9

TABLE 4 (Continued)

	P. O. J. 213		P. O. J. 234		P. O. J. 234	
	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent
Tops and Stubble (green)	13,577.0	...	8,897.0	...	10,416.0	...
Roots (dry) in different layers:						
0- 2 inches	38.85	18.7	21.35	10.7	11.60	6.2
3- 8 inches	120.40	57.9	114.50	57.3	115.35	61.5
9-14 inches	31.60	15.2	42.25	21.2	38.10	20.3
15-24 inches	10.45	5.0	12.40	6.2	14.45	7.7
25-30 inches	6.40	3.0	9.35	4.5	7.85	4.2
31-36 inches						
Total	207.70	99.8	199.85	99.9	187.35	99.9

TABLE 4 (Continued)

	P. O. J. 36		P. O. J. 36		P. O. J. 213 Stubble		P. O. J. 213 Stubble	
	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent
Tops and stubble (green)	11,802.0	...	18,157.0	...	12,001.0	...	18,526.0	...
Roots (dry) in different layers:								
0- 2 inches	10.80	6.3	28.80	12.9	44.20	11.4	73.10	19.9
3- 8 inches	108.00	68.2	132.45	59.7	245.00	63.0	162.95	44.5
9-14 inches	31.80	20.1	43.00	19.4	38.15	9.8	77.80	21.2
15-24 inches	6.55	4.1	12.50	5.6	28.60	7.3	30.80	8.4
25-30 inches	1.70	1.0	5.1	2.3	18.75	4.8	12.80	3.5
31-36 inches					14.10	3.6	8.80	2.4
Total	158.25	99.7	221.85	99.9	388.80	99.9	366.25	99.9

It will be seen that the roots penetrated to depths of more than 30 to 36 inches. In fact, some of these roots were traced down to depths of more than four feet. Of greatest importance is the fact that from 85 to 90% of the roots were found in the surface fourteen inches of soil. The deeper roots undoubtedly furnish moisture for the plants during dry periods, yet most of the absorption of water and mineral salts must come from the surface layers.

In the season of 1930, further excavations were made during a drought period in the last half of June and the first half of July the results obtained are given in Table 5. In this table, each set of figures represents the average of two stools.

TABLE 5

WEIGHT AND DISTRIBUTION OF ROOTS AND SHOOTS OF STOOLS OF CANE, JUNE AND JULY, 1930.

	Co. 281		P. O. J. 36 M		P. O. J. 213		Co. 281	
	Plant Mixed soil		Plant Mixed soil		Plant Mixed soil		Plant Heavy soil	
	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent
Tops and Stubble (dry)	534.7	..	745.0	...	320.3	...	218.7	...
Roots (dry) in different layers:								
0- 2 inches	0.	0.	0.	0.	1.9	2.1	0.	0.
3- 8 inches	65.70	51.9	54.90	45.5	46.9	51.9	56.1	71.3
9-14 inches	53.95	42.6	47.90	39.8	30.9	34.2	18.0	22.9
15-24 inches	6.90	5.4	17.60	14.6	10.6	11.6	4.4	5.5
Total	126.55	99.9	120.50	99.9	90.3	99.8	78.5	99.8
Ratio of roots to tops	1 to 4.2		1 to 6.1		1 to 3.5		1 to 2.8	

TABLE 5 (Continued)

	P. O. J. 36 M		P. O. J. 213		P. O. J. 36 M	
	Plant Heavy soil		Plant Heavy soil		1st Yr. Stubble Heavy soil	
	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent
Tops and stubble (dry) ...	160.5	...	167.9	...	774.9	...
Roots (dry) in different layers:						
0- 2 inches	0.0	0.0	0.0	0.0	0.0	0.0
3- 8 inches	28.9	71.3	27.4	58.8	113.9	73.9
9-14 inches	10.4	25.6	14.2	30.4	24.7	16.0
15-24 inches	1.2	2.9	5.0	10.7	15.5	10.0
Total	40.5	99.8	46.6	99.9	154.1	99.9
Ratio of roots to tops ...	1 to 3.9		1 to 3.6		1 to 5.0	

TABLE 5 (Continued)

	P. O. J. 213		C. P. 807		Co. 281	
	1st Yr. Stubble Heavy soil		Plant Mixed soil		1st Yr. Stubble Mixed soil	
	Weight grams	Per cent	Weight grams	Per cent	Weight grams	Per cent
Tops and stubble (dry) ..	357.5	..	1,515.0	..	2,486.5	...
Roots (dry) in different layers:						
0- 2 inches	0.0	0.0	2.4	1.1	10.0	3.7
3- 8 inches	39.2	48.5	109.1	50.2	173.9	65.6
9-14 inches	20.8	25.7	81.5	37.5	55.8	21.0
15-24 inches	20.9	25.8	24.0	11.0	25.0	9.4
Total	80.9	100.0	217.0	99.8	264.7	99.7
Ratio of roots to tops.....	1 to 4.4		1 to 6.9		1 to 9.4	

The results given in the table show that at this period of growth, there were from forty-five to seventy per cent of the roots in the top eight inches of soil and from eighty-five to ninety-five per cent in the top fourteen inches. These results agree quite closely with those obtained in the previous fall. In general, the cane in heavy soil showed a greater percentage of the roots in the upper eight inches of soil than cane in mixed soil. The lighter soils are of a looser texture and are better aerated, conditions which favor root penetration and development.

GERMINATION OF PLANTED CANE

In Louisiana, in order to insure a proper stand, the ordinary procedure is to plant two running stalks. The entire stalk is used and two solid rows of these are placed in the opened furrow at planting time. These stalks are usually lapped in order to make an even distribution of the top and basal eyes. The major portion of the cane acreage is planted in early October. The rest is largely planted in the early spring, using seed cane which has been windrowed.

After planting, the buds on the tops of the stalks are usually the first to swell and start to develop shoots. This does not mean, however, that tops will produce a better stand of cane. On the contrary, from observations made over many years in Louisiana, it has been found that the number of shoots produced in the field from basal buds usually averages slightly higher than from top eyes. This is due to the fact that the top joints are more tender and consequently deteriorate more rapidly and possibly also to the fact that the seedpiece roots develop better on the basal joints. Cane varieties also seem to vary in this respect. An excellent example of this variation occurred in one of the tests on the experiment station farm in 1931. A large number of stalks of P. O. J. 234 and P. O. J. 213 were planted separately, each being marked by stakes. In June, it was noticed that shoots from the P. O. J. 234 stalks were larger at the top of the stalk and gradually became smaller towards the base. With the P. O. J. 213, the reverse was true. The large shoots came from the base of the stalks, the tops of the stalks producing small shoots or none at all.

Information on the number of shoots that can be expected from planted cane is of importance. Formerly when the old varieties, D 74, Striped, and Purple, were generally planted, information accumulated over a number of years showed that on the average only about twenty per cent of the eyes produced shoots.

During the past four years, data on germination have been obtained with the new varieties. This has been secured by counting the good buds on the cane planted in certain plots and then in the spring counting the number of shoots which developed. In Table 6 is given the information which has been obtained since 1928.

TABLE 6

GERMINATION OF BUDS ON PLANTED SEED CANE

Variety	1928		1929		1930		1931	
	April 19	May 7	March 28	April 30	April 10	May 5	April 6	May 4
P. O. J. 213	20.8	25.0	11.0	22.0	17.87	24.23	7.2	14.59
P. O. J. 234	16.5	20.4	15.0	27.0	25.72	30.08	14.5	26.36
P. O. J. 36	17.8	21.5	13.0	26.0	10.85	16.89	......	......
P. O. J. 36 M	......	......	......	......	12.59	18.01	2.9	15.08
C. P. 177	......	......	......	......	40.13	48.38	24.9	31.01
Co. 281	......	......	......	......	21.45	34.38	12.2	20.22
C. P. 807	......	......	......	......	28.61	33.87	22.6	23.28
Co. 290	......	......	......	......	......	......	20.2	22.30
La. Purple	3.8	3.8	6.0	13.0	1.26	3.16	8.1	15.83
D 74	11.4	13.2	8.0	20.0	4.89	10.34	6.7	19.28

The canes which are at present being grown in the State have during a period of four years shown an average germination of between 20 and 30%. Under Louisiana conditions, it is probable that a germination better than 30% cannot be expected. During the four years, P.O.J. 234 has perhaps shown the most consistent germination.

The poor germination of canes in Louisiana results from a combination of factors including the red rot disease which attacks the stalks, root rotting organisms including Pythium which destroy the seedpiece roots, and environmental factors, such as temperature, drainage and aeration of soil. The consistent good germination of P. O. J. 234 is at least partially due to its resistance to the red rot disease. Louisiana Purple is extremely susceptible to red rot and the poor germination in 1928 and 1930 was unquestionably due to this disease.

RECOVERY OF STUBBLE CANE

When cane is cut in the fall, the rootstocks or stubble pieces which consist of short pieces containing from five to ten short joints are left in the soil. Each of these joints contains an eye or bud which under satisfactory conditions can produce a new shoot. As has been stated, the reproduction of these stubble pieces is very similar to that of planted cane with the exception that the stubble does not ordinarily produce new roots but instead depends on the old roots of the previous season. The deterioration of stubble is and has been one of the most important problems in sugar agriculture in Louisiana. The deterioration, as with plant cane, results largely from two causes: (1) a rotting of the stubble pieces by red rot and other organisms and (2) a failure of the root system due to unfavorable soil conditions or to the attack of soil organisms.

A careful study has been made of the recovery of stubble cane during two very unlike seasons, 1929-30 and 1930-31.

In the fall of 1929, the cane had reached maturity at harvest time and the weather conditions were such that many of the basal eyes had developed or were swelling. After the cane was cut, these buds continued to develop and many produced shoots in the fall. Many of these shoots that developed in the fall were completely killed by the cold winter which followed.

On the other hand at harvest time in 1930, cane was in an immature condition. Very few of the basal eyes had developed or were even swollen. As a result, the production of shoots in the fall was very much less than in the previous year. In the following spring, the shoots to a considerable extent came from the upper living eyes on the stubble pieces. This is probably a more normal recovery of the stubble pieces than the condition which occurred in 1930.

During both years, weather conditions in the spring were unfavorable and there was excessive deterioration of the stubble pieces. Much of this was due to red rot but undoubtedly a portion of it resulted from a failure of the old roots to function.

Stubbles which develop excessively in the fall unquestionably deteriorate more than those which develop slower. Stubble from early cut cane consequently is frequently more severely injured than from late cut cane. A cane like P. O. J. 234 which develops quickly and will grow at a low temperature is often hurt severely by early cutting. On the other hand, varieties like Co. 281, which start more slowly in the fall and require higher temperatures for growth will stand early cutting much better.

The factors which cause the deterioration of stubble cane become worse from year to year. Consequently it is only a matter of time before the stands in fields are materially reduced. With the varieties at present in use, two stubble crops are ordinarily all that can be expected. With some of the more easily injured varieties like P. O. J. 213, the second stubble crop will often be a failure.

GROWTH OF ROOTS AND SHOOTS

The comparative growth of roots and shoots is information of value especially in relation to cultivation practices. During three years, measurements have been made of roots and shoots in the early spring during the period that the roots are growing out into the middles. In the following tables, this information is tabulated. In Table 7, is included the length of the roots and shoots at weekly intervals during the spring of 1930, while in Table 8 are given the results on important dates during three years. The stalk height represents the distance between the seed-piece in the soil and the highest visible leaf sheath ring. The root length is the distance the roots extend out into the middles in the upper six to eight inches of soil. In each case, the figures are based on an average of ten plants.

TABLE 7

ROOT AND SHOOT GROWTH, 1930, MEASURED IN INCHES

Variety	Date	Mixed Soil		Heavy soil	
		Stalks	Roots	Stalks	Roots
C. P. 807 Plant Cane	April 17	6.9	1.8	5.9	0.1
	April 26	6.9	1.3	6.2	2.6
	May 2	7.5	2.3	7.8	3.1
	May 9	9.1	5.2	8.3	6.7
	May 15	9.7	6.0	10.5	11.1
	May 23	14.3	8.9	....	....
	May 29	12.9	11.1	13.7	12.8
	June 6	21.0	23.6	15.6	18.2
Co. 281 Plant Cane	April 17	7.0	2.7	6.8	2.1
	April 26	7.6	1.9	8.1	1.8
	May 2	8.7	2.6	8.6	3.5
	May 9	9.0	5.2	9.1	8.4
	May 15	9.6	6.1	9.8	8.2
	May 23	11.9	10.6	....	....
	May 29	12.1	10.3	11.5	10.1
	June 6	17.7	23.7	13.1	14.9
P. O. J. 234 Plant Cane	April 17	6.8	0.1	6.3	....
	April 26	8.6	1.5	7.2	3.9
	May 2	8.7	3.9	7.2	2.9
	May 9	9.5	4.2	7.9	5.0
	May 15	11.6	5.8	....	....
	May 23	10.4	6.4	....	....
	May 29	11.1	11.6	8.3	7.5
	June 6	16.1	21.9	10.7	13.0
P. O. J. 213 Plant Cane	April 17	6.3	1.7	5.3	0.8
	April 26	7.2	1.8	6.9	2.0
	May 2	7.2	2.8	6.2	0.9
	May 9	8.1	6.1	7.9	7.1
	May 15	8.7	4.0	....	....
	May 23	10.1	7.3	....	....
	May 29	12.2	11.3	9.7	8.9
	June 6	13.6	24.8	11.9	17.0

TABLE 7 (Continued)

Variety	Date	Mixed Soil		Heavy soil	
		Stalks	Roots	Stalks	Roots
P. O. J. 36 M Plant Cane	April 17	8.2	1.2	5.5	0.9
	April 26	8.4	3.7	7.0	1.9
	May 2	7.7	2.2	8.1	2.8
	May 9	9.5	4.7	8.6	5.8
	May 15	10.3	5.9	9.5	9.4
	May 23	11.0	8.3	....	....
	May 29	13.4	13.0	10.4	9.3
	June 6	16.5	29.5	12.6	18.8
P. O. J. 36 M Early Cut Stubble	April 26	8.5	2.1	7.4	0.0
	May 2	8.5	3.0	8.0	0.9
	May 9	9.3	6.0	8.3	2.7
	May 15	....	....	....	....
	May 23	12.8	8.3	11.5	4.8
	May 29	13.3	13.3	13.2	11.8
	June 6	17.0	23.3	14.0	18.0
P. O. J. 36 M Late Cut Stubble	April 26	8.1	2.0	6.9	0.5
	May 2	9.3	3.3	9.1	0.9
	May 9	8.5	4.2	8.0	2.1
	May 15	....	....	....	....
	May 23	11.6	5.6	10.5	2.8
	May 29	13.2	12.0	10.9	9.2
	June 6	15.2	21.1	14.0	17.1
P. O. J. 213 Early Cut Stubble	April 26	6.6	1.1	....	....
	May 2	7.1	1.1	....	....
	May 9	8.0	1.9	....	....
	May 15	9.1	1.9	....	....
	May 23	8.5	4.0	....	....
	May 29	9.4	9.8	....	....
	June 6	11.3	15.2	....	....
P. O. J. 213 Late Cut Stubble	April 26	6.8	1.0	....	....
	May 2	8.0	2.0	....	....
	May 9	8.5	3.5	....	....
	May 15	10.2	5.5	....	....
	May 23	11.0	4.8	....	....
	May 29	11.5	12.6	....	....
	June 6	14.8	22.2	....	....
P. O. J. 234 Late Cut Stubble	April 26	5.5	0.1	....	....
	May 2	8.3	3.2	....	....
	May 9	7.7	1.3	....	....
	May 15	9.6	3.7	....	....
	May 23	7.8	3.6	....	....
	May 29	12.2	7.0	....	....
	June 6	13.9	16.8	....	....
Co. 281 Late Cut	May 2	9.7	1.9	....	....
	May 9	11.4	5.1	....	....
	May 15	....	....	....	....
	May 23	14.2	7.6	....	....
	May 29	16.5	12.6	....	....
	June 6	20.1	24.8	....	....

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TABLE 8

YEARLY VARIATIONS IN ROOT AND SHOOT GROWTH, MEASURED IN INCHES

Variety	Date	1929		1930		1931	
		Shoot	Root	Shoot	Root	Shoot	Root
P. O. J. 213 Plant Cane	May 14-15	8.2	19.6	8.7	4.0	6.6	4.5
	May 22-23	12.5	24.5	10.1	7.3	8.2	9.6
	May 29-30	14.2	29.7	12.2	11.3	9.9	11.4
	June 5-6..	......	......	13.6	24.8	12.2	19.1
P. O. J. 36 Plant Cane	May 14 ..	8.6	17.9	......	......	......	......
	May 22 ..	13.5	25.5	......	......	......	......
	May 30 ..	16.5	34.3	......	......	......	......
P. O. J. 36 M Plant Cane	May 15 ..	......	......	10.3	5.9	7.0	4.2
	May 22-23	......	......	11.0	8.3	8.1	8.0
	May 29-30	......	......	13.4	13.0	9.6	9.2
	June 5-6 .	......	......	16.5	29.5	12.2	16.7
P. O. J. 234 Plant Cane	May 14-15	11.2	17.3	......	......	......	......
	May 22-23	12.2	18.9	10.4	6.4	......	......
	May 29-30	17.1	27.4	11.1	11.6	......	......
	June 5-6 .	......	......	16.1	21.9	15.8	20.0
C. P. 807 Plant Cane	May 15 ..	......	......	9.7	6.0	9.8	7.5
	May 22-23	......	......	14.3	8.9	9.6	8.5
	May 29-30	......	......	12.9	11.1	10.9	10.2
	June 5-6 .	......	.....	21.0	23.6	14.0	17.5
Co. 281 Plant Cane	May 15 ..	......	......	9.6	6.1	8.1	5.2
	May 22-23	......	......	11.9	10.6	8.7	6.3
	May 29-30	......	......	12.1	10.3	9.9	10.0
	June 5-6 .	......	......	17.7	23.7	13.6	17.5
Co. 290 Plant Cane	May 15 ..	......	......	......	......	9.1	9.6
	May 22 ..	......	......	......	......	11.3	12.2
	May 30 ..	......	......	......	......	10.8	9.7
	June 5 ..	......	......	......	......	15.9	23.1

TABLE 8 (Continued)

Variety	Date	1930		1931	
		Shoot	Root	Shoot	Root
P. O. J. 213 Stubble Cane	May 15	10.2	5.5	7.8	2.9
	May 22-23	11.0	4.8	8.6	5.9
	May 29-30	11.5	12.6	9.1	9.7
	June 5-6	14.8	22.2	11.5	14.4
P. O. J. 36 M Stubble Cane	May 15	....	....	9.0	3.2
	May 22-23	11.6	5.6	9.1	4.1
	May 29-30	13.2	12.0	10.8	9.8
	June 5-6	15.2	21.1	13.8	17.8
P. O. J. 234 Stubble Cane	May 15	9.6	3.7	9.3	5.7
	May 22-23	7.8	3.6	9.7	8.6
	May 29-30	12.2	7.0	11.8	11.4
	June 5-6	13.9	16.8	13.2	16.3
C. P. 807 Stubble Cane	May 15	....	....	10.9	5.8
	May 22-23	....	....	11.0	6.0
	May 29-30	....	....	12.3	10.2
	June 5-6	....	....	16.8	22.9
Co. 281 Stubble Cane	May 15	....	....	9.3	5.5
	May 22-23	14.2	7.6	9.9	5.3
	May 29-30	16.5	12.6	11.5	10.3
	June 5-6	20.1	24.8	13.8	19.6

The spring of 1929 was very favorable for cane growth. The cane developed much faster than in either of the succeeding years. It is important to note that in that spring the root length was practically twice that of the stalk height. On May 14 when the stalks were eight to eleven inches high, the roots were seventeen to nineteen inches in length, long enough to be injured by deep cultivation and by May 30, the roots were meeting in the middles. In 1930 and 1931, the roots were less than twice as long as the shoots and canes twelve to thirteen inches in height did not have roots long enough to be seriously injured by cultivation. In 1930, the middle of the row was not reached by any great number of roots until after June 6. In 1931, the growth was even slower than in 1930. From the three years results, it would seem that deep cultivation should be discontinued some time between May 14 and June 6, depending upon the advancement of the season.

DISCUSSION

It is generally recognized that the Louisiana planter is working under certain handicaps in the growing of sugar cane which do not exist in the tropics. The seed cane is planted in the fall and must be maintained through a partially dormant period of several months, during which conditions are often unfavorable. Furthermore the cane crop must be made in a short growing season of seven to eight months. In the tropics, cane usually grows for twelve to eighteen months and sometimes longer. It is readily seen that the time factor is extremely important in Louisiana. The growth of cane must start in the spring as early as possible and it must be maintained through every day of the growing season if satisfactory yields are to be obtained.

As the growth of any plant depends very largely upon its root system, it necessarily follows that maximum crops of cane can only be made with plants with well-developed roots that are functioning properly. In this bulletin some of the factors affecting root development and growth have been discussed. It has been shown that both the germination of the buds and the growth of the plants are affected by the condition of the roots and it has been demonstrated that the cane yields are often reduced on account of a failure of the roots to function as they should. It seems self-evident then, that in all field practices, including soil preparation, cultivation, drainage, and fertilization, everything possible should be done to keep the roots in a healthy condition and growing rapidly.

The studies which have been made have brought out the importance of several things.

(1) The seedpiece roots are important in the early growth of plant cane. These are easily destroyed by root-rotting organisms. Better drainage and the raising of the temperature of the soil by the judicious removal of soil from above the seedpieces should be beneficial in the maintenance of these roots.

(2) The old roots on the stubble pieces are important in the early growth of the young shoots. Too severe prun-

ing of these roots by off-barring or other cultivation practices in the winter or early spring before the young shoots have made a good start may frequently be harmful.

(3) The cutting of the feeding roots in the upper soil layers during cultivation may be harmful and this should be prevented as far as possible. It is recognized that new roots can be produced very rapidly under favorable conditions but under other conditions severe root pruning must result in a retarded growth.

(4) On the other hand, a loose aerated soil is favorable for root development. A maximum growth cannot ordinarily be maintained without cultivation. Deep cultivation, then, should precede the development of the roots in the upper soil layers. From three years' results, it has been shown that deep cultivation even in the middles should be stopped sometimes between May 14 and June 5.

SUMMARY

1. The primary roots of the sugar cane plant develop from the root band area on the internode of the stalk just above the node.

2. Roots will develop from any joint when moisture and temperature conditions are favorable. Under field conditions, root development only occurs normally on the underground part of the stalk, the rootstock.

3. Roots absorb water and mineral salts from the soil. The younger portions of the root carry on the function of absorption. The older portion of the root, after it has become dark in color, merely transports the soil solution back to the stalk. For a root to be functioning normally, it should be in a growing condition.

4. After planting, roots develop on the seedpieces. These maintain the young shoots until these develop roots of their own. The destruction of these seedpiece roots checks the growth of the cane in the spring. These roots are frequently destroyed by root-rotting organisms.

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5. Shoots from stubble cane depend upon the old roots on the stubble pieces. If these roots are destroyed or injured, fewer shoots will develop and the growth of these will be checked.

6. A loose and well-aerated soil is favorable for root development.

7. Cane grows best at high temperatures. The minimum temperature for growth varies with differet varieties. The minimum temperature for P. O. J. 213 and P. O. J. 36 M is about 54°F, while for Co. 281, it is about 57.5°F. At these low temperatures, growth is very slow and the roots decay readily.

8. The first roots to develop seem to go directly downward in the soil. Later, the roots spread outward and become massed in the surface layers. While roots extend downward for more than four feet, usually from eighty-five to ninety-five per cent of them are in the upper fourteen inches of soil.

9. The canes which are now being grown in the State show an average germination between twenty and thirty per cent.

10. The question of stubble deterioration is closely associated with the growth of roots and shoots in the fall. Varieties like Co. 281, which start slowly in the fall and require a higher temperature for growth do not deteriorate as severely as some of the others.

11. The rapidity of growth of roots and shoots varies from year to year. In 1929, roots reached the middle of the row between May 22 and May 30. In 1931, they had not reached the middles by June 5. In 1929, the root length was nearly twice as great as the height of the shoots. In the two following years, the roots were not as long.

12. The studies have emphasized the importance of keeping the roots in a rapidly growing condition. The destruction of roots by cultivation practices should be prevented as far as possible.

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